# TRANSACTIONS

OF

# THE AMERICAN SOCIETY

OF

# HEATING AND VENTILATING ENGINEERS

VOL. III.

THIRD ANNUAL MEETING,

NEW YORK, JANUARY 26-28,

1897.

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AT THE OFFICE OF THE SECRETARY,
NEW YORK CITY.

# OFFICERS

OF

# THE AMERICAN SOCIETY

OF

# Heating and Ventilating Engineers.

## 1897-1898.

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# COMMITTEES

OF

# THE AMERICAN SOCIETY

OF

# Heating and Ventilating Engineers,

## 1897-1898.

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W. F. Wolfe, Boston, Mass.
S. A. Jellett, Philadelphia.
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### UNIFORM CONTRACT AND SPECIFICATIONS.

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D. M. Quay, Chicago.
J. J. Blackmore, New York.
A. E. Kenrick, Brookline, Mass.
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### NOMINATIONS.

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F. W. Foster, Boston.
John Gormly, Philadelphia.
T. J. Waters, Chicago.
Homer Adams, Allentown, Pa.

XXIII.

# PROCEEDINGS

## OF THE

# AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

### THIRD ANNUAL MEETING.

**New York City, Jan. 26, 27, and 28, 1897.**

### OPENING SESSION, TUESDAY MORNING, JAN. 26.

The third annual meeting of the American Society of Heating and Ventilating Engineers was called to order at 11 A. M. on Tuesday, January 26, 1897, by the President, Prof. R. C. Carpenter, in the hall of the American Society of Mechanical Engineers, 12 West Thirty-first street, New York.

The President:—The hour for opening the meeting has passed, but on account of an unfortunate and very lamentable circumstance it was not possible to call the meeting together earlier. The first proceeding on the order of business is the roll call of members. Mr. Wadsworth will call the roll for the secretary.

Mr. Wadsworth called the roll, and the following members were present:

Adams, Homer.
Andrus, N. P.
Barron, H. J.
Bennett, W. B.
Blackmore, George C.
Blackmore, J. J.
Blackmore, L. R.
Brooks, Ernest J.
Cary, A. A.
Carpenter, B. Harold.
Carpenter, Prof. R. C.
Clark, W. H.
Cobb, George B.
Connolly, John A.
Cryer, Albert A.
Cryer, Thos. B.
Davidson, W. H. A.
Davidson, McC.
Dewey, W. H.
Edgar, A. C.
Fish, John A.
Fowler, A. H.
Goodrich, J. A.
Gormly, John.
Harvey, A. D.
Hauss, C. F.
Hill, W. H.
Hopkins, C. S.
Jellett, Stewart A.
Joslin, Herbert A.
Kenrick, A. E.
Lincoln, C. C.
Mappett, A. S.
McKiever, W. H.
McMannis, W.
Mott, A. C.
Munro, Edward A.
Paul, A. G.
Quay, D. M.
Scollay, U. G.
Seward, P. H.
Sherman, L. B.
Stangland, B. F.
Thompson, Thomas.
Wendover, J. R.
Weymouth, Geo. H.
Wilkinson, W. B.
Williams, Francis A.
Wolfe, Wiltsie F.

The President:—I have just received this letter, which was in a

very great measure a shock to me, but with the contents of which I think you are generally familiar:

NEW YORK, Jan. 26, 1897.

Prof. R. C. Carpenter,
President A. S. H. V. E.

Dear Sir:—It is with profound regret that I am compelled to notify you at the opening of this meeting of the sudden death of our secretary, Mr. L. H. Hart, who died of heart failure at 11 Montague Terrace, Brooklyn, at half-past five yesterday afternoon. Brief services will be held by the Odd Fellows at this place at eight o'clock Tuesday evening (that is to-night), to which members of the society are invited. The interment will take place at Unionville, Conn., Wednesday, at 1:30 P. M.

Very respectfully yours,

H. M. SWETLAND.

In view of the very sudden death of Mr. Hart, arrangements have been made that Mr. Wadsworth shall act as temporary secretary until the vacancy can be filled by a regular election.

The reading of the minutes of the previous meeting having been dispensed with, they having been published in the transactions of the society, the president announced the next order of business as being the presentation of the president's address, which was then read.

The President:—The next order of business is the reading of the secretary's report.

Mr. Wadsworth:—Your former secretary having been taken sick before he could prepare a report, no report can be made at this time.

The President:—Next in order is the report of the treasurer.

### TREASURER'S REPORT.

Your treasurer begs to submit the following report:

| | |
|---|---|
| Cash on hand Jan. 20th, 1896, as per last report. | $373 26 |
| Cash received since that date.................. | 845 65 |
| | $1,218 91 |
| Disbursements............................ | 1,042 63 |
| Balance on hand in Washington Trust Co...... | $176 28 |

There are no unpaid bills in the hands of the treasurer except one for stamps and stationery, amounting to $4.78, which is submitted herewith. No report has been received from the secretary as to what, if anything, is due for initiation fees or dues.

The President:—Gentlemen, you have heard the report of the treasurer. Is there any action to be taken in connection with it? We

will pass it by for the time being. Next in order is the report of the chairman of the board of managers.

Mr. W. M. Mackay read the following report:

REPORT OF BOARD OF MANAGERS.

Your board of managers have held regular meetings at stated intervals since the last annual meeting, attending to all business requiring their attention or brought to their notice. At their first meeting the annual proceedings were ordered printed; at their second meeting the revised constitution was ordered printed and distributed to the members; at their third meeting a committee was appointed at the request of the Society of Physicians and Surgeons to form a joint committee to investigate the effect of the humidity of air in ventilation; at their fourth meeting certificates of membership were ordered engraved, the date of the annual meeting was decided on, and a resolution presented by Prof. Carpenter, and intended to remove a wrong impression which seemed to exist in regard to the qualifications for membership, was adopted and ordered sent to the members; at the fifth meeting a committee was appointed to examine the treasurer's books (which were found correct), and to execute his bond; a resolution was adopted that all members two years in arrears for dues be dropped from the rolls. At the sixth and seventh meetings matters in connection with the annual meeting were attended to. The attendance at all the meetings of the board has been large, and although some of the members have had to come from a distance at considerable inconvenience and loss of time, they have willingly given their time and have shown a marked interest in the welfare of the society. The membership certificates have been engraved and will be forwarded to the members as soon as they are filled in and signed by the president and secretary.

There have been complaints made as to the length of time taken in acting on applications for membership during the past year, and it has been suggested that there should be a stated time after an application is received by the secretary during which it should be acted on either favorably or adversely.

The President:—I believe there is no action. Next in order is the report of the chairman of the council.

Mr. J. J. Blackmore presented the following report:

REPORT OF COUNCIL.

Your council have to report the folowing facts in relation to the growth of the society during the past year. We received eleven applications for membership, as follows: Eight full members, two

associate, and one junior member. These will be balloted for at the present meeting. The society has sustained the loss of two members by death during the year, Mr. J. J. Hogan, Middletown, N. Y., and Mr. L. H. Hart, Brooklyn, N. Y., our late secretary.

The membership of the society, not counting those to be balloted for, numbers 108, one of which is honorary, seven associate, and one junior. The council has closely scrutinized all applications for membership, that no one should be accepted but those fully qualified by a knowledge of the principles of heating and ventilation. We have not considered the fact as to whether the applicant was a manufacturer, a salesman, or mechanic, but we required ample proof that applicants were entitled to rank as heating and ventilating engineers before being endorsed for membership. This high standard the present council respectfully commend to their successors in office.

The council have considered the matter of offering prizes for competition papers to the junior members of the society, but do not consider it advisable to make such an offer till the society has 20 juniors to compete for the prizes.

The papers and topics presented for the consideration of the members have been selected with care in the hope that they would keep a prominent rank in the literature of the craft. The council desire to remind the members that all the papers presented for consideration should contain something more than mere assertions; that if a member makes a statement that one article or system is superior to another he is expected to explain why he came to such a conclusion, otherwise the paper would not be of value to the society. Members are also reminded that it is better to present topics for the purpose of provoking discussion than to write a paper for such a purpose.

The council desire to call the attention of the members to the fact that the society has high aims and objects in view, and only courteous action of the members one towards another will enable us to carry out these desires. Whatever the opposition (in the exigencies of trade) that may exist between firms or individuals should never come into the society, and all discussions that take place in the society should be conducted in a friendly manner and with a view to bringing out all the information possible.

If care and judgment is used on these lines, the published proceedings of the society will soon be accorded high rank as exponents of scientific progress. The council are of the opinion that the proceedings of the society should be reviewed by them before being finally passed to the printer for publication.

The present members are of the opinion that the powers and duties of the council should be more clearly defined, as it is difficult to determine how far their duties extend in relation to the publications of the society.

The President:—Gentlemen, you have heard the report of the council. Is there any action to be taken regarding it? If not, we will take up the papers of the session.

Mr. Wadsworth:—Shall I read the list of new members?

Mr. Kenrick:—Wouldn't it be well that the report of the council be accepted and placed on file?

The President:—I think so. Is there a motion to that effect?

Mr. Kenrick:—I make that a motion. (Motion carried.)

The President:—The secretary will announce the names of the new members.

Mr. Wadsworth, the acting secretary, announced the election to membership in the society of the following gentlemen: Fred. D. Johnson, New York; Abram Cox Mott, Philadelphia, Pa.; Edward P. Waggoner, Jersey City, N. J.; John Hopson, Jr., New London, Conn.; C. C. Buck, Boston, Mass.; Andres Borch Reck, Copenhagen, Denmark; Charles M. Wilkes, Chicago, Ill.; Arthur H. Fowler, Philadelphia, Pa., as members; Ernest J. Brooks, Bridgeport, Conn.; Byron E. Van Auken, Chicago, Ill., as associates, and James T. McElfatrick, Ft. Wayne, Ind., as a junior member.

The President:—Next in order are the reports of special committees.

Mr. B. H. Carpenter, secretary of the committee on compulsory legislation, presented that committee's report, as follows:

### REPORT OF COMMITTEE ON COMPULSORY LEGISLATION.

Mr. President and gentlemen, I have no written report yet prepared, but would say that I have written to the president of the board of health of every state in the Union the following letter, with a view to getting a consensus of opinion on the subject of compulsory legislation:

"The American Society of Heating and Ventilating Engineers has a committee appointed whose object is the furtherance of a uniform law throughout the various states for the compulsory heating and ventilating of the better class of public buildings, and it will greatly facilitate the work of the committee to gain from you replies to the following questions:

"Has your state any laws governing the important matter of heat and ventilation in public buildings?

"If so, what are the chief requirements?

"Is any movement on foot looking towards this result?

"Do you not consider that the enactment and rigid enforcement of such a law would work untold benefits, particularly in churches, opera houses, public schools, asylums, and hospitals?

"Some states have enacted some very wise legislation in this regard—Massachusetts being particularly noticeable.

"The committee on standards of our society has recommended the following:

"That for all buildings, such as schools and asylums occupied almost entirely by children and youths under 15 years of age, the minimum amount of air for ventilation shall be 1,800 cubic feet per hour per person.

"That for all buildings occupied by persons over 15 years of age, the minimum amount of air for ventilation shall be 2,000 cubic feet per hour per person.

"That for buildings lighted in part or wholly by gas, the minimum amount of air supplied for each gas light shall be 3,000 cubic feet per hour.

"In this connection it may be not amiss to state that the recognized authorities on this important subject fully concur in the above recommendations, but space forbids the insertion of the full text of their opinions at this time. However, you can readily see the object of our society and the unquestioned wisdom of appointing a committee to thoroughly traverse this important ground, and aside from securing the most enlightened and practical ideas and opinions on a subject so vitality connected with the health of our kind we desire to disseminate the enthusiasm—if we may use the term—and earnestly summon your most valuable assistance in securing the desired legislation."

To this letter I have received fifty or sixty replies, the letter having also been sent to state superintendents of schools. With one exception all indorsed what was suggested and expressed a desire to help the cause along. The representative of one southern state said he thought there was too much law at the present time and that he did not care to have any more.

As I have said, no report has been framed from these letters. Mr. Mackay handed me this morning a copy of an address delivered by our late secretary, Mr. Hart, before a meeting of representative men in the ventilating business, which he had called together at the Fifth Avenue Hotel, New York, on December 15, for the purpose of considering ways and means to secure the enactment of compulsory ven-

tilation laws, Mr. Mackay saying it might be well to read it here. The address is as follows:

GENTLEMEN: As I have been one of the factors, especially in the way of correspondence, in calling you together, I feel that perhaps it is proper for me to open the discussion upon the subject which has brought us here. As you all know, I have been interested, since 1893, in a publication which is devoted to the interests of better ventilation. During that time I have observed the agitation for better and purer air grow from a consideration of little moment to one that to-day is interesting all classes. Every day greater and greater interest is being taken in the subject, not only by our school boards, but by the public at large, especially where our people have been aroused, where epidemics of fatal diseases raged, traced in many cases to impure air. We have all heard of the law in relation to ventilation in the state of Massachusetts, as that is our only state in which we have anything of the sort. This law has been a good one, but it has operated outside of the city of Boston. In the city of Boston, where the state inspectors had no jurisdiction, the schools were in such shape that last year a committee of experts was appointed to make a report to the governor and council upon the exact state of their school houses, especially from a sanitary standpoint. I had some conversation with one of these experts, and he told me that it would take $2,000,000 to put these schools into proper sanitary condition. He also informed me that in one case the connections from the closets were made directly into the ground below them and not properly laid. The pipe had become broken, and for a long while all the excrement had been allowed to sink into the ground at that point, the foul air from it passing up through the pipes into the school rooms. To show the utter disregard as to the health of the children the Hillside school, Jamaica Plain, Boston, Mass., within two years has been fitted with open urinals placed in the basement, in which are located heating coils below the school room floor, which is not protected by lath or plaster and through which the action of the heat makes large gaps, allowing the foul air to mingle with the air of the room. As yet the city of Boston has no legislation as has the rest of Massachusetts, and what is the result; there has been a squabble ever since the report of this committee was made as to whom should have the spending of the $300,000 which was appropriated as a commencement in the way of a reform, and instead of allowing one of our competent engineers to lay out a model school for them, that should be perfect in its ventilation, some one has been employed who, judging from the specifications, appears to

be one who has yet a great deal to learn. However, these are but incidents.

In 1894 the American Society of Heating and Ventilating Engineers was formed, composed mostly of engineers engaged in installing heating or ventilating plants. One of the objects of the society is to establish a clearly defined minimum standard of heating and ventilation for all classes of buildings, to favor legislation to compel the ventilation of all public buildings in accordance with the standard of the society. Since that time the society has been busy gathering data from all over the world. The consensus of opinion is that for schools the law should be 1,800 cubic feet per hour per capita and that 2,000 cubic feet would be a liberal allowance. In the sittings of court houses it has been suggested that 1,000 cubic feet per unit of floor space per hour would be enough. In the matter of jails or state prisons between 1,000 and 2,000 cubic feet, for hospitals and poor houses 3,000 cubic feet per bed per hour. Rufus R. Wade, Chief of the Massachusetts District Police, wrote the society as follows: "In answer to your request that I give you my ideas on the matter of compulsory legislation relating to the matter of ventilation of buildings, I would say that the present legislation on the subject in this state is the result of the broadening of sanitary laws which were applied to factories and workshops. I am of the opinion that legislation of this character, to be effective, must embrace factories, workshops, schools, and public buildings. To accomplish what has been done in this state, and to secure the results obtained, has required untiring effort and has been a laborious and oftentimes a discouraging task. To educate the public concerning the correct principles of ventilation it has been necessary to stem the tide of indifference and arouse a sense of responsibility.

"It is a curious fact that these elementary laws of public health are not accepted without resistance. The inertia of popular indifference is an obstacle whose power it would not be easy to over-estimate. What has been done in this state can be done in others. The laws under which we act and which are accepted by the public generally, and are cheerfully complied with will be found in the pamphlet herewith enclosed. I am gratified to learn that your society is about to commence a crusade in the interest of securing perfect sanitary conditions in your public schoolhouses and other public buildings; but success demands ceaseless vigilance and the most persistent presentation of the facts gathered by daily observation. As you truthfully write, it is a broad subject and will require much time and labor. This department has established the rule that 30 cubic feet of fresh

air per minute shall be furnished each scholar during the school session. When plans are submitted to us showing methods of heating and ventilation we require guarantees that results shall come fully up to the standard. In public buildings 15 cubic feet per minute, and this amount is the minimum. Our law is now working well and I shall not ask for further legislation on the subject."

In the pamphlet enclosed by Chief Wade appear the following clauses:

"Sect. 33. Every factory in which five or more persons are employed and every factory, workshop, mercantile, or other establishment or office in which two or more children, young persons, or women are employed shall be kept in a cleanly state and free from effluvia arising from any drain, privy, or other nuisance, and shall be provided, within reasonable access, with a sufficient number of water closets, earth closets, or privies for the reasonable use of the persons employed therein; and wherever two or more male persons and two or more female persons are employed as aforesaid together, a sufficient number of separate and distinct water closets, earth closets, or privies shall be provided for the use of each sex, and plainly designated; and no person shall be allowed to use any such closet or privy assigned to persons of the other sex.

"Sect. 37. Every factory in which five or more persons are employed and every workshop in which five or more children, young persons, or women are employed shall, while work is carried on therein, be so ventilated that the air shall not become so exhausted or impure as to be injurious to the health of the persons employed therein, and shall be so ventilated as to render harmless, so far as is practicable, all gases, vapors, dust, or other impurities generated in the course of the manufacturing process or handicraft carried on therein, which may be injurious to health.

"Sect. 38. If in a workshop or factory included in Sect. 37 of this act any process is carried on by which dust is generated and inhaled to an injurious extent by the persons employed therein, and it appears to an inspector of factories that such inhalation could be to a great extent prevented by the use of a fan or by other mechanical means, and that the same can be provided without incurring unreasonable expense, such inspector may direct a fan or other mechanical means of proper construction to be provided within a reasonable time, and such fan or other mechanical means shall be so provided, maintained, and used.

"Sect. 39. No criminal prosecution shall be instituted for any violation of the provisions of sections 37 and 38 of this act unless such

employer shall have neglected for four weeks to make such changes in his factory or workshop as shall have been ordered by an inspector of factories by a notice in writing delivered to or received by such employer."

"Sect. 40. Every public building and every schoolhouse shall be kept in a cleanly state and free from effluvia arising from any drain privy, or other nuisance, and shall be provided with a sufficient number of proper water closets, earth closets, or privies for the reasonable use of the pupils attending such schoolhouse.

"Sect. 41. Every public building and every schoolhouse shall be ventilated in such a proper manner that the air shall not become so exhausted as to become injurious to the health of the persons present therein. The provisions of this section and the preceding section shall be enforced by the inspection department of the district police.

"Sect. 42. Whenever it appears to an inspector of factories and public buildings that further and different sanitary provisions or means of ventilation are required in any public building or schoolhouse, in order to conform to the requirements of this act, and that the same can be provided without incurring unreasonable expense, such inspector may issue a written order to the proper person or authority directing such sanitary provisions or means of ventilation to be provided, and they shall thereupon be provided, in accordance with such order, by the public authority, corporation, or person having charge of, owning, or leasing such public building or schoolhouse.

"Sect. 43. Any school committee, public officer, corporation, or person shall within four weeks after the receipt of an order from an inspector, as provided in the preceding section, provide the sanitary provisions or means of ventilation required thereby."

The writer believes the public can soon be aroused to the fact that they are every day endangering the health of their children in many of our public schools in this country which are improperly ventilated. The New York Herald some two or three years ago made a crusade on this subject in the city of New York, which resulted in the appropriation of $5,000,000 for schools in this city, which is now being expended, and our schools are being rapidly put into proper condition, and all new schools are being properly heated and ventilated. Public buildings, however, are not receiving the attention they should receive on this vital subject. In the New York Herald, October 22d, 1896, the following communication appeared: "It is fully time that the board of health were making and enforcing laws regarding ventilation of factories, slop shops, and other places where

working women are forced to congregate. Many a weakly woman has lost her life from consumption, or had it rendered a burden from catarrh, through the ignorance of some fellow worker, with the constitution of an alligator, who has lowered one of the windows out of all reason. This is a case in which woman needs to be defended against woman, as I believe there are no fresh air fiends among men."

As to tenements, last year a committee, of which Richard Watson Gilder was chairman, made a thorough investigation as to the sanitary condition of the tenements in New York city, and their report says that they were in an awful condition. The result of their report has been that a building association has been formed to build tenements for the poorer class, which shall be well lighted and ventilated. A very good law has been passed in England in relation to ventilation, the text of which I think will be given here at this meeting by Mr. Morse, who was to bring a copy of it with him. As I understand it, this law has resulted in a largely increased business for the Blackman Fan Co. in England, as well as in benefiting the public by a decreased death rate. Mr. George Peck, of the Peck-Williamson Heating and Ventilating Co., Cincinnati, was in my office some few days since, and said to me that he is now getting out a book upon the subject of heating and ventilation and that he proposes to put it in the hands of the public very largely, and he is going to use all the efforts he possibly can to secure proper ventilation in some of our Western states. This subject is not only one which interests the public, but one which should interest you, gentlemen, more than any one else. You are primarily interested in this subject because you manufacture the goods which are used. The more apparatus used the more you will sell and the more benefit should accrue to you. Personally I shall be glad to lend a hand through the columns of "Heating and Ventilation," and will promise you that you can have all the space you desire to agitate this subject. We will also reprint for you in pamphlet form, at cost to us, any matter which has been prepared upon this subject and which has appeared in our columns. In most of our different states the legislature meets in January. If we can settle upon a proper bill to be presented at that time and the matter is followed up, so that when a hearing is to be had on the bill some one representing yourselves may be there to see that the cause is properly taken care of, most excellent results should accrue. I believe I am correct in saying that I can promise you the hearty support of the American Society of Heating and Ventilating Engineers, and that if necessary Prof.

Woodbridge, Prof. Carpenter, Mr. Gouge, and others may be secured to go before these committees and explain the subject properly.

Mr. Gouge introduced a bill in the New York legislature last year, and I understand that the representative who introduced it has received many letters from people in the state commending it and wishing very much that it might pass. Many of these letters were from school teachers, who had to teach all day in badly ventilated rooms, and there was practically no objection to the bill passing, the only trouble was that it was not followed up. The public can be easily aroused at this time, and in trying to secure legislation of this sort you, gentlemen, must remember that is it not simply a mercenary motive on your part, but that you are doing a public service, which will be of very lasting benefit.

I trust the discussion here may be favorable and that we may settle upon a law which will be satisfactory, and that ways and means may be provided to get a good start this next year in the matter of necessary legislation for the proper ventilation of our public and private buildings.

Mr. B. H. Carpenter:—I might state that several of the answers to the letter previously read speak of the various legislatures being, or would be so soon, in session that it would be impossible to get it before that legislature, but that if we would frame laws on the subject the writers would be very glad to present them to the state board of health and would do what they could to have them passed. I have also sent this letter to some local boards of health in Pennsylvania, where it was endorsed. It would be an impossibility to have the same law passed in the different states, and for that reason I do not see how this committee would be able to work the subject out alone. They make take Pennsylvania and work it up for that state, and some of the New York members could do the same for this state, but we could not get up a law that would answer for all states.

The President:—Would it not be possible to get up a draft of general provisions similar to the Massachusetts law, which could, with slight modifications, be used in the different states?

Mr. Carpenter:—Yes; I think that might be done. Here is an act that was prepared by our late secretary, Mr. Hart, and submitted to the Connecticut legislature:

# AN ACT

### TO SECURE PROPER SANITARY CONDITIONS AND PROPER VENTILATION IN PUBLIC BUILDINGS AND SCHOOL HOUSES.

The people of the state of Connecticut, represented in senate and assembly, do enact as follows:

Sect. 1. Every public building and every schoolhouse shall be kept in a cleanly state and free from effluvia arising from any drain, privy, or other nuisance, and shall be provided with a sufficient number of proper water-closets, earth-closets, or privies for the reasonable use of persons admitted to such public building or attending such schoolhouse.

Sect. 2. Every public building and every schoolhouse shall be ventilated in such manner that the quantity of foul or vitiated air exhausted or removed shall not be less than the amount that has been demonstrated as good practice by the laws of other states for each person, and the quantity of fresh air admitted shall not be less than the amount that has been demonstrated as good practice by the laws of other states for each person that such public building or schoolhouse can accommodate. The provisions of this section and the preceding section shall be enforced in each city, village, town, or county by the board of health thereof. It is made the duty of such boards of health within six months from and after the passage of this act, to inspect all the buildings then in use within the meaning of this act, and thereafter to inspect all buildings which shall be applied to the uses herein recited. It is further made the duty of any such board of health, upon application in writing by any such person interested for an inspection, of any public building or schoolhouse, to make such inspection within a reasonable time, not exceeding one month after the receipt of such written application, provided that such board of health, in its discretion, may refuse to inspect any public building or schoolhouse which appears from its records to have been inspected within the six months next preceding. And in every case such inspection shall include the determination of the quantities of air actually removed and introduced and their sufficiency under this act.

Sect. 3. Whenever it shall appear to the proper board of health, upon inspection of any public building or schoolhouse, that the sanitary provisions or means of ventilation thereof are insufficient to conform to the requirements of this act, and that the same can be made sufficient without unreasonable expense, such board of health shall issue a written order to the proper person or authority directing

such sanitary provisions or means of ventilation to be supplied, and the same shall thereupon be supplied by the public authority, corporation, or person having charge of, owning, or leasing such public building or schoolhouse.

Sect. 4. Any public officer, corporation, or person neglecting for four weeks after the receipt of a written order from the proper board of health, as hereinbefore provided, to supply the sanitary provisions or means of ventilation required thereby, shall be punished by a fine of one hundred dollars. If any board of school trustees shall for a like period of time fail to comply with the requirements of such written order from the proper board of health, each member of such board of trustees shall be punished by a fine of one hundred dollars; provided, however, that in any case wherein the board of health is satisfied that such failure to comply is unavoidable, and that the trustees, public officer, corporation, or person responsible is in good faith preparing to comply with such order, this penalty may be remitted.

Sect. 5. Whenever it shall appear to the proper board of health that a written order, given under the fourth section hereof, has not been obeyed within one month after its delivery to the proper person or authority, such board of health shall have the power, and it is hereby made its duty, to prohibit the use of such public building or schoolhouse until the requirements of such order are complied with, it being provided that such action shall not be taken by such board of health if it shall be satisfied that the failure to comply is unavoidable and the trustees, public officer, corporation, or person responsible is in good faith preparing to comply with the requirements of the order.

Sect. 6. The expression "public building" used in this act shall include any public building or premises used as a place of public entertainment, instruction, resort, or assemblage. The expression "schoolhouse" shall mean any building or premises in which instruction is afforded to not less than ten pupils at one time.

Sect. 7. This act shall take effect upon its ratification.

Mr. Blackmore:—The question has been raised that it is not possible to draft any form of law that would be acceptable to all the states. While I agree with that view to a certain extent, we know that in dealing with the question of heating and ventilating there are certain laws we have to follow, and anything coming from this society should be suggestive, I believe, and I do not see any reason why we could not set forth in a suggestive form the principles involved and the best way to produce the result we are after, i. e., good

heating and ventilation, particularly ventilation. It is a well known fact that the air in a room needs to be changed a given number of times per hour, or each person requires so many cubic feet of air per hour, to keep the room in a proper sanitary condition. Why a general set of rules or suggestions cannot be framed for the information of the different health boards throughout the country and cannot be adopted is something that I cannot see. Of course, the details would have to be left to the legislatures which pass these different acts, but the essential features should be the same all through, because the principles are exactly the same in every state. As regards the draft of the act just read, it seems to me it is very indefinite, and if we are going to recommend anything of the kind, we ought to be very clear in what we recommend, because we must have in view the fact that the men who take these things in hand are nearly always impracticable, and the matter needs to be stated very clearly so that they can appreciate the subject that they have in hand.

Mr. Mackay:—I would state that while Mr. Carpenter made the statement referred to by Mr. Blackmore, in connection with the report, it was not meant that the basic laws would not be followed out. In fact, the state law of Massachusetts was used as a ground work in preparing the law last year for the New York legislature, and also that for the Connecticut and New Jersey legislatures. If we can get a law that will at least better matters in the different states, it will be a move in the right direction. That has been the idea of those working on this question. If we presented a bill so radical that it would not be adopted, we would accomplish nothing. If, on the other hand, we presented a bill that would meet the views of legislators, and better the condition of the public buildings, we would have accomplished something, and having that for a ground work, we could later work on other legislatures and accomplish more in the same direction.

Mr. B. Harold Carpenter:—There are several states in the Union that have some laws on the subject of compulsory ventilation, as will be shown by the letters that I have, but they are not enforced. In one case where the statute is very definite in stating what the board of health shall do that body has no money to do it and so it is not done. That the same law will not apply to the different states is mentioned in a letter which I received from Mr. S. A. Jellett last year and which was read before the board. He states that we ought to have a controlling body, and I think, to bring this about in the right manner, we should not only make our law general, but also give some idea as to who are the parties to enforce it, making an

allowance from the state each year for that purpose. The chief with his assistants enforces the law in Massachusetts; we could not make that law a general one, because some of the states have that already, as Massachusetts has. The boards of health and the superintendents of schools, as shown by these replies, are very anxious to help the matter along and will do all that they can. I think that the question is now ripe to be taken up and pushed forward, and I think that, if done rightly, we can accomplish a great deal. We will have to see that they not only pass a law for giving a certain amount of air but also pass a law allowing a certain amount of money to be spent in the accomplishment of it.

Mr. Cary:—In making a draft of these requirements I think is more the business of a lawyer than of one who is inexperienced in that class of work, and I think if such drafts are made by a man who is acccustomed to that work that they will command more attention before a legislature, and the better the matter is presented, of course, the more quickly it will be taken up. I believe in putting ourselves squarely before the legislature and asking what we want. What we do not ask for we won't get, and I think that the society should state what it wants as clearly as possible. Then legislators will consider what they wish to accept and what they wish to reject. It is pretty hard to pick a law up after it has once been made and make amendments to it. I think it should be enacted as well as possible in the first place, and we should do all in our power to put it into good shape, so that very little will have to be done, and there will be no pretext for the members of the legislature to tear it all to pieces.

Mr. Mackay:—These opinions were obtained in getting up these acts and wherever a legislature or members of it were approached, the state law of Massachusetts was cited and the requirements mentioned, as you will notice in Mr. Hart's address at the Fifth Avenue Hotel. Why they were not included in some of these laws was the fault of the other side, and if we made a law so rigid that they would not take it up, we would be wasting our time. We had to work through the other body, and while we could ask them for all we wanted we could only present to them such things as they would accept.

Mr. Wolfe:—All of you gentlemen who have come in contact with local boards of health know that they are made up of politicians; they seek the suffrage of their people, and if they are going to impose upon a town an expense of from $1,000 to $5,000, as the case may be, for changing a building, the taxpayers, almost to a unit, are going to say, "We don't need it. We went to school forty years ago

in such and such a building and we are all right, and we don't need to spend any such money. We can pay $2.50 to put in a window ventilator and that is good enough." I believe, if we are going to have anything of this kind and make it successful, that there should be one central board, preferably the state board of health in my judgment, which should have full power to direct the local boards of health; and they should be able to obtain all necessary information and to test a school thoroughly, whether it is right and proper, or any public building, and we should not mix up our factories with our schools. That has been tried in Massachusetts with success. There were so many inspectors set aside to do nothing but the public buildings; others that attended to the factory work, others to the fisheries, and others to the sale of liquor, &c. It is all under a general head, but divided into departments. Now, the state board of health is made up of intelligent and eminent men who can afford to buy the apparatus necessary and acquire the information necessary to ascertain that the buildings are in proper sanitary condition. They would be glad to get it. It would give them an amount of authority they have not had before, and I believe that they would join with us. It must come to them from the society which has made a study of it, and I believe that a bill can be passed in any legislature and in almost any state. The state law of Massachusetts is very indefinite. "When in the judgment of the inspector the sanitary conditions of a building are such as to require changes, etc., they will be ordered made." That is an indefinite law. There is what they call Form 83 in Massachusetts, which says that certain results have been accomplished in thousands of buildings and are right and satisfactory, that is, 30 cubic feet of air per minute, etc., given as a recommendation that should be followed as soon as possible, not as a mandatory law—simply a suggestion. I believe that a similar recommendation for the boards of health to follow should be made, but I do not believe that we want to mix up the factory inspectors with the law as to compulsory ventilation. Take the state of Connecticut; How many factory inspectors do you suppose they have to look after that state? They have just one. He has his hands pretty full. The minute you go to the local board of health and make their power absolute in their own town, they are going to pay more attention to the wishes of the tax payers than they are to anything else. Make it as non-partisan as possible. Of course, that board in Boston is subject only to the governor; he appoints them or he dismisses them; they simply do their duty regardless of who votes for them or who does not, and I believe in having the local boards of

health subject to the orders of the state board. In that way you will eliminate the political end of it and the views of taxpayers who do not want to spend money. At the request of Mr. Hart I have seen some of the boards of health and I think they would join you gladly in anything of the kind. If you want to go before a legislature or any legislative committee or any public body, you can simply quote what the department of Massachusetts says is actually a fact, viz., they can prove by the statistics that the enforcement of the law in the state of Massachusetts has resulted in a reduction in the death rate of school children as twelve is to four. You do not need any better argument than that.

Mr. Kenrick:—I would ask Mr. Wolfe if the state board of Massachusetts do not compel us to make Form 83 part and parcel of our specifications.

Mr. Wolfe:—Oh, yes; we have to include that in our guarantee. But that is simply a business matter; they won't pay a bill unless we agree to comply with Form 83.

Mr. Barron:—I think this committee has done excellent work and I think they have done it in a practical way. It is a political question entirely, and anything that we may recommend will have an entirely different shape when it gets on the statute books. Theoretical gentlemen say we ought to have a rigid platform. When you go into a political matter with a rigid platform you are a crank and do not acccomplish anything. The only way you can get anything is to compromise and take what you can get. We have got one state—Massachusetts. Let us get another one and another one. Hit them at one point at a time, and even if we only get an amendment to our factory act it would accomplish what we want. Get a good man, a competent heating and ventilating engineer appointed as factory inspector and he will carry out the law to your satisfaction.

Mr. Cary:—I agree with Mr. Barron about compromise, but I do not believe in beginning by compromising. I think to start right off from a square standpoint is better.

Mr. B. H. Carpenter:—I have found the letter which Mr. Connolly has requested me to read. The fourth question is: "Do you not consider the enactment and rigid enforcement of such a law would work untold benefits, particularly in churches, opera houses, public schools, asylums, and hospitals?" and the answer to that question is: "I believe in more liberty and less law." At the end of the letter he says: "If you can persuade the builders of churches and public buildings generally to do these things, it will not hurt anybody, but may do good. But force of law applied, or attempted to be applied, begets

opposition and you may put the state in conflict with its citizens over matters which the average citizen thinks is his individual province and business to have or not to have, as he may choose. I am not a centralist, but believe in 'more liberty and less law.'

(Signed) "JOHN C. SCARBOROUGH, State Supt.,
"Pub. Inst'n, Raleigh, N. C."

Mr. Barron:—I think that gentleman's position is perfectly right.

The President:—Is there any further discussion on this very important subject?

Mr. Jellett:—Does that complete the report of the committee? The report ought really not to be discussed until the committee has finished.

The President:—That is the complete report. Is there any more discussion on the subject? It is a very important work.

Mr. Wolfe:—Mr. President, is it not right that we should act now, during this meeting, with a view to having a law passed or endeavoring to have it passed in one city or one town or one state or as many as we can? Ought we not to request this committee to report, or have the committee increased, if desirable, and have them devise some basis upon which a law could be formulated, and let us concentrate our efforts on the city of New York or the state of New York or somewhere else? We have gone so far, and if it is accepted with thanks and laid on the table, what will be done? These gentlemen have had nothing for their trouble, and we are no nearer our purpose than when we started. If we mean business, let us do it. If we do not, there is no need of having such a committee.

Mr. Jellett:—This is one of our standing committees. It does not cease to exist when it makes a report. I was about to suggest that the present committee before the end of this meeting, that is, before Thursday's session, draft a form of law which will cover the requirements. We can state in it the minimum amount of air that should be given and that it should be admitted not lower than a certain degree of temperature. Those are the two particular points. And they could also make suggestions as to the manner of its enforcement; that is, the matter of inspection to see that the act is carried out. It is simply a collection of suggestions that could be framed, in the hands of a competent legislative lawyer, into a proper bill. I think the committee, with the data at hand, can very readily frame such an outline, and I suggest that they be requested to do it before the end of the session.

The President:—Is that a motion?

Mr. Jellett:—I make it as a motion; yes, sir. (Seconded.)

The President:—It is moved and seconded that the committee on compulsory legislation be instructed to report a definite means of action before the end of the session.

Mr. Wolfe:—I beg to differ with Mr. Jellett to the extent that I do not believe we could draw a law which should be specific as to the amount of air that should be introduced and exhausted from a room, nor its temperature. I do not believe any better precedent could be followed than the clause of the Massachusetts law which says "When in the judgment of an inspector." It is for the committee to decide, of course, whether it is best to have a clause to the effect that—it may be a board of health man or state factory inspector, who ever it is—when in the judgment of such a person the sanitary conditions were found to be such as to endanger the lives and health of the occupants of the building, certain changes could be ordered made by him. Then, simply as a recommendatory measure, not as a part of the law to be enacted, but as a line to be followed out in the formation of the law by the people who make it, let the committee embody something like Form 83 of Massachusetts, which gives the results in so many schools and says what can so easily be done. It is a good deal easier to let a man think that he is doing a thing himself than to make him do what he thinks you want him to do—driving him. You must give him this little, gentle hint and let him make a law to fit it, and he will be much better satisfied with it than if you make it for him, and I think you can get it through more easily.

Mr. Jellett:—I do not altogether agree with Mr. Wolfe, I admit that we should ask for a minimum and not for a maximum, but it should be for a definite amount. If you leave it to the judgment of each individual inspector, you might have forty different judgments. I have read over several sections of the Massachusetts law under which some inspectors would very readily pass things which inspectors in other districts would not pass. I have seen the same things in sanitary questions coming up before board of health inspectors. I remember distinctly a question I brought before an inspector of the Philadelphia board of health some years ago. The law said positively a certain thing should not be done, but he stood there in the building and allowed something else to be done which did not conflict with the strict wording of the letter of the law, which accomplished exactly the same results as though the letter had been violated. His attention was called to that, and he said: "The law does not say so and so, and anything that the law does not say is left to my discretion. I will pass that." It was a clear violation

of the law, if ever there was a violation, and he simply fell back on the letter of his law. That is going to happen as long as we have individual judgment not guided by anything definite. We can say that we want a minimum amount of air—in Massachusetts they suggest that certain things be done in a school. Why don't they say: "This having been done in other schools we will require you to do it in yours." If they have not money to carry it out you cannot enforce such enactment until there is money to pay for it. But it does not weaken the law any to take that fixed position. I think that we should suggest a minimum amount and try to work towards that point. If we get more, why the better we are off.

Mr. Wolfe:—I wish what Mr. Jellett says about the Massachusetts law was right; it would make it easier for us. This is the way they do it: There is a school house either altered or newly built and the apparatus put in. The inspector of the district makes his inspection. When he goes into office he is put under oath to tell the truth. He puts his report in figures and it is sent to the department, and if it does not comply with the requirements of Form 83, we get a little letter from the committee stating that Chief Wade begs to call attention to the fact that the requirements have not been fulfilled and the school cannot be accepted by the department until they are. We are not told anything about where we lack. We have the pleasure of going up and getting at the report and finding wherein we failed. The inspectors go in a building and they recommend alterations, the chief sends out the order, and then when the inspection is made the report goes back to the chief, he reports back to the committee, and the committee very naturally to the people who did the work.

Mr. Jellett:—That is all I am asking—that there shall be something definite. You evidently have to toe the line up there. You have to conform with Form 83.

Mr. Wolfe:—You may call it what you say is a minimum. It is not for me to say whether it is right or not. Their minimum is 30 cubic feet. They do not object to 95 feet. I know one school where they gave 95 feet of air per capita and that was not condemned.

Mr. Jellett:—The point I raised is you are required to meet a certain condition.

Mr. Wolfe:—Yes, sir.

Mr. Jellett:—That is what I am asking for here—a minimum condition. We want the line drawn and to come up to the line; that is all.

Mr. Wolfe:—I think more can be gained by making it discretionary with the board of health and bring to bear on them the force that we can have; they to make something similar to what we call Form 83. The law is mandatory that they shall comply with the requirements of the inspector, but they do not say specifically in the law just how much air there must be. Then the department in the district gets out this order, and if we do not comply with it we do not get our money. That is simply given as an illustration.

Mr. Jellett:—The only difference I notice is that the Massachusetts law puts up Form 83 as a suggestion; then they make an order to the inspector: "You must see it carried out"; so that the re-One is a suggestion to the contractor and the other is a positive order to the inspector. "You must see it carried out"; so that the result is the same.

Mr. B. H. Carpenter:—I think that several of these letters ask for something of that kind, and if there is a form they will assist in getting it through the legislature, and the board of health can do much more with it right in the state than we can. I think it would help a great deal in having some form that we can send out.

Mr. Wolfe:—I have been told that anything of this kind that we care to have carried through would be considered much more carefully as a request by a society of this character than it would by any individual, particularly if that individual has apparatus to sell.

The President:—Interrupting this discussion, I will say there is here a notice that lunch will be ready at twelve in this building. It is now a little past twelve and I would suggest that we accept the courtesy of the New York members, who have provided this luncheon, and adjourn now until one o'clock or a quarter past that hour.

Mr. Cary:—Is there not a motion before the house that should be passed upon before we have luncheon? I think we have wandered from it.

The President:—If the discussion with reference to that motion is through, we will vote on the motion before recess.

Mr. Wolfe:—I move that we adjourn until 1:15 P. M. and take up again the undisposed of motion. (Carried.)

## AFTERNOON SESSION.

President Carpenter called the meeting to order at 1.45 P. M.

Mr. Jellett:—Mr. President, as the committee on compulsory legislation are to report later on, and as the committee on uniform contract and specifications are not yet entirely ready to report, I would suggest that we take up the papers and allow these committee re-

ports to go over to a later period in our session, when they can be more completely handled and discussed, if that meets with the sense of the members here.

The President:—Is that made as a motion—that we postpone for the time being the further reports of committees and take up the literary matter of the convention?

Mr. Jellett:—I make that a motion; yes, sir.

The President:—The motion is now made that we postpone the consideration of the motion before the house until we can get a farther report from the committee. (Carried.)

The President:—The amendment is carried and the discussion on this question will be postponed until the farther report of the committee.

Mr. Barron:—Can we vote on the original motion now? The amendment having been carried, the original motion ought to be put. (Motion put and carried.)

The President:—As I understand the matter, the original motion, although it gave time to the committee, did not speak of discussion. The amendment postponed the discussion until after we get their report. Now both the amendment and the original motion have been carried, which puts both the report and the discussion thereon for Thursday morning. That is the way the matter stands as I understand it now.

Mr. B. H. Carpenter:—Mr. President, there were five members of this committee, Mr. Harding being one. He is now out of this line of business I believe. Would it not be well to appoint a fifth member, so that he can work with us on this question.

Mr. Jellett:—That would come in under the new committees on the last day.

The President:—If it is the wish of the society I will appoint Mr. Alfred E. Kenrick of Brookline to act on the committee for the remaining portion of this session.

Mr. Kenrick:—I should like to decline in favor of Mr. Wolfe. I think he would be a good man on the committee.

A Member:—Mr. Wolfe is already on the committee.

The President:—The next order of business is the appointment of tellers. The new constitution provides for the opening of the letter ballot during the session. Since the ballots were sent out one of our candidates, Mr. Hart, the secretary of the society, has died. This will doubtless make some changes necessary in the ballots, and for that reason it has been thought best to announce that the ballot will not be closed until to-morrow afternoon at 4 o'clock, and that the

last vote cast, which should be properly dated, by any member of the society will be the only one which will be counted by the tellers. I would appoint as tellers Mr. John A. Connolly, Mr. McClellan Davidson, and Mr. Alfred E. Kenrick, and I would ask that they take charge of the ballots cast for the various officers and determine who is elected and make a report as soon as possible. I will allow the ballot to remain open until 4 P. M. to-morrow, which will give ample time to make any necessary changes in the ballots.

Mr. Wolfe:—Owing to the unfortunate occurrence of Mr. Hart's death, are not the nominating committee obliged to nominate another secretary, in accordance with the constitution and by-laws? I think they are. I think there must be two candidates for each office, if I am not mistaken.

The President:—I have gone into this matter rather carefully on account of some questions that have been raised. It is my impression that this is not necessary and could not be done, from the very fact that the nominations by the nominating committee must be made some time in advance of the general meeting. On the other hand, and as an offset to this disadvantage, you will find that there is no provision in our constitution which requires any member of our society to vote for the members named by the nominating committee. They have the opportunity of voting for any one they desire. Consequently this matter can come before us legally without any nomination, and I doubt if any regular nomination can be made at this time. I am sure it cannot, because it requires sixty days under the constitution. You have the right to vote for anybody and whoever receives a majority of your votes will certainly be elected.

Mr. Wolfe:—It has been suggested to me that the by-laws can be suspended by unanimous vote and a nominating committee appointed, if the gentlemen see fit.

Mr. Jellett:—That does not come under the by-laws.

The President:—Unfortunately, that provision is in the constitution—not in the by-laws.

Mr. Wolfe:—It is not that I object to the remaining candidate. It is simply a question of the legality of the election.

The President:—I will read the constitution referring to the vote and you will see that it does not require a vote for the person named by the nominating committee. It says:

"Any member entitled to vote may vote by retaining or changing the names on said list, leaving names not exceeding in number the officers to be elected and returning the list to the secretary—such ballots enclosed in two envelopes, the inner one to be blank and the

outer one to be endorsed by the voter. No member or associate in arrears since the last annual meeting shall be allowed to vote until said arrears shall have been paid."

It seems that the constitution contemplates allowing the members to nominate their own officers if they desire. It says, in reference to the nominating committee:

"The chair will select a nominating committee"—previous to this it says sixty days in advance of the annual meeting—"which shall consist of five members * * * whose duty it shall be to present to the secretary within ten days after appointment of date of annual meeting"—that is fifty days before the annual meeting—"the names of two candidates for each position to be voted for."

But as we do not need the action of any nominating committee, I would suggest that we—

Mr. Kenrick:—Is there any question that could be raised in the hereafter in regard to the legality of these officers elected by discarding the votes of members who have voted in good faith and returned their votes to the secretary? By the action of this meeting you propose to discard all those votes returned to the secretary by members who have voted according to the constitution.

The President:—It would seem to me that every vote which is now in the hands of the secretary and has not been superseded by a later vote must be counted. Unfortunately, on account of the death of Mr. Hart, there may be a good many votes for him, which of course cannot have weight. But aside from that I cannot see how any question of legality can be raised, especially in the light of that provision of the constitution which I have just read.

Mr. Wolfe:—But a man having voted upon the receipt of what he supposed to be the official ballot as made up by the nominating committee—having voted on that, we will say, for all except Mr. Hart (he might not have voted for him)—must not that ballot stand?

The President:—I should rule that a person can do in this society as he can do in any other society, especially since there is nothing stated to the contrary—that he can change his vote as many times as he sees fit, provided that the votes are dated and the last vote is marked so as to be identified with certainty. That is the customary proceeding in societies regarding such matters, and I believe it is the customary way when a man makes his will to supersede all others by the last one made.

Mr. Wolfe:—I will state my position exactly in the matter. I have voted according to the printed ballot, without any changes whatever,

as made by the nominating committee appointed by the chair, and I have received several notices since of certain changes being made, etc. If I vote for these men according to the constitution, which says that I must return my vote in a given time, doesn't it invalidate all my votes cast, as I am entitled to vote but once? I am only asking for information, because I voted the ballot sent to me.

Mr. Jellett:—Mr. President, I think the simpler way is to take no action on the vote for secretary until after the present ballot has been closed. There are a number of our members who have voted on this question who are not here and who will not be here. They are entitled to consideration. Now if Mr. Hart has received the majority of votes, Mr. Hart should be declared elected. Due to the death of Mr. Hart there would be a vacancy to be filled, and the membership in session at an annual meeting can always fill a vacancy. I think that is common law in any society. So that after the vote is in we can take up the question of the secretaryship as a separate vote altogether, because we would then know whether an actual vacancy exists. We cannot prejudge that the vote is going to be a majority for Mr. Hart.

The President:—I should certainly consider that the explanation of Mr. Jellett would apply to the case.

Mr. Wolfe:—Yes; we have no right to take away the suffrage of the absent members. That is certain.

The President:—If there is no further discussion on this point, the next—

Mr. Kenrick:—I think there might be something more said in the matter, and that is in regard to the time the vote shall be opened.

The President:—Which will be 4 o'clock to-morrow afternoon.

Mr. Kenrick:—Does it not say in the constitution the next day, or something of the kind?

Several members:—No.

Mr. Wolfe:—We cannot distinguish, among ourselves, who are present as against those who are absent. If my vote is in it is in, and the vote of a man who is away and whose vote has been cast is in also. It is not just that I should have a chance to change mine and we have no oportunity to change his.

Mr. Jellett:—I think the election to fill a vacancy is the simplest way.

Mr. T. B. Cryer:—If I am in order, I should like to make a motion that we open the ballots, and then we can see who is elected and who is not elected. It is early in the meeting, and we could then make our

choice of a secretary if necessary, and that will give us time to consider whom we should like for a secretary.

The President:—If that is made as a motion I think it would be in order.

Mr. Cary:—I was not here in the early part of this discussion, I am sorry to say, so I do not know what has been said; but I think there is a regular order of business, is there not, which should be followed?

The President:—This does not come under the regular order of business. Consequently it can be regulated by motion.

Mr. Cary:—I think by turning to our by-laws on the last page it will be found that the election of officers is to take place at the last meeting.

Mr. Mackay:—It is the intention that they shall take office at the last meeting. That was decided at the meeting of the board of managers, with respect to yourself, Mr. President, and Mr. Jellett, the idea being that you were ushered into your office in the midst of a session, and you both objected to it, and it was thereupon made a motion by the board of managers that the newly elected officers should take their positions at that time. They are elected when the vote is counted at the annual meeting.

The President:—It seems to me we are wasting a great deal of the time of the society over a matter which could better be done by the committee, and I would rule, if there is no objection to it, that the committee of tellers shall look into this matter and report to the society as soon as agreeable.

Mr. Wolfe:—I move that the suggestion of the chair be carried out. (Seconded.)

Mr. Cary:—The committee of tellers have the power to count the votes and to make their report. I believe that is the limit of their power. Having no power beyond that, this would be giving them power which would establish a precedent—

The President:—Oh, no, sir.

Mr. Cary:—And would be irregular, I am afraid.

The President:—The only point in question is in regard to the time of their making that report. It was previously stated that the time should be after 4 o'clock to-morrow afternoon. On account of the questions that have been raised, I now suggest that they be allowed to make their report when they are ready, and unless there is objection to that, or unless it is opposed by motion, I should decide that way.

Mr. Wolfe:—I move that the suggestion of the chair be followed.

Mr. Jellett:—I move that we take up the papers on the program. (Seconded and carried.)

Mr. Blackmore:—A great many members, I understand, have not put their ballots in. I have not myself. Will it not be necessary for you, Mr. President, to set a time up to which those ballots will be received. If the committee of tellers decide to report in 15 minutes, there will be a number not turned in.

Mr. Cary :—That I know to be the fact.

Mr. Barron :—In order to dispose of this matter and get it off our hands, I would suggest that it be left to the third day, as usual, or that the tellers report on the last day or to-morrow, just as they elect.

Mr. Wolfe:—I would amend that by leaving it to the discretion of the chair to say when the ballot shall close and when the tellers shall report.

Mr. Cary:—I second that if that amendment can be substituted. (Amendment substituted and motion carried.)

The President:—The chair is inclined to announce, on account of the points raised by Mr. Blackmore, that the ballots should close by the beginning of our session to-morrow afternoon. I will say 3 o'clock. There being no evening session this day, that will be our next session. What is the further pleasure of the meeting?

Mr. B. H. Carpenter :—I move, before we begin the reading of papers, if that is next in order, that we give a vote of thanks to the New York members for the repast they gave us in the room below. (Seconded and carried.)

Mr. Kenrick:—I should like to make a motion that the American Society of Heating and Ventilating Engineers contribute a floral tribute to the funeral of our late secretary, Mr. Hart.

Mr. Cary:—I think that a motion put in that way would call upon the treasurer of the society. But I think there are a great many members here present who would be willing to start a fund toward the object in view, and if it is done individually it will be just as gratefully received and just as gracefully put.

Mr. Wolfe:—I do not object to the floral tribute; I would second that from the bottom of my heart. But when we speak of acting as individuals, it should be remembered that Mr. Hart has not served us individually ; he has served us as a society, and it is right and proper for us to recognize the service as a society.

The President :—I should think the motion would be in order. (Carried.)

Mr. Wolfe :—I move that the president appoint a committee of one

or more to tender this floral tribute to Mr. Hart's family forthwith.

Mr. Kenrick:—I move as an amendment to Mr. Wolfe's motion that the whole matter be placed with the board of managers with full power. (Motion carried.)

The President:—The board of managers are authorized to prepare the necessary floral tribute.

There is also another motion that I think should receive the attention of the society, which is submitted in writing by Mr. Wilson:

"I wish to make a motion that a committee of three be appointed to draw up resolutions of condolence and respect in regard to the death of John J. Hogan, of Middletown, N. Y., a member of the society, and that such resolutions be spread upon the minutes of this meeting and a copy of this resolution be sent to his family." (Motion seconded and carried.)

The President :—Various suggestions regarding action of the society have been made in some of the reports which may require, if carried out, amendments to the constitution. This is the case with the report of the council, the report of the board of managers, and the address of your president. It would strike the Chair that it might be in order to appoint a committee to consider these various recommendations and make a report at the last session of this meeting. Otherwise they are not likely to be acted upon.

Mr. Blackmore:—I move that such a committee be appointed as you suggest. (Seconded.)

The President:—For various reasons I should prefer that the society name that committee.

Mr. Blackmore:—I will change my motion and put it in this form —that the Chair appoint a committee to consider and report on the advisability of making any changes on the lines that have been suggested in the various reports. (Carried.)

The President:—My objection to appointing the committee is due to the fact that I suggested several changes, and the Chair should prefer for that reason, that the committee should be named by the members not interested.

Mr. Cary:—I believe that it would be a pretty difficult thing to do. It might facilitate matters if the Chair would offer names to the membership.

The President:—The committee will be appointed at the beginning of our next session.

The first of the papers for the afternoon session is on "Separation of Oil and Grease from Exhaust Steam," by William J. Baldwin. Mr. Baldwin makes a special request to have his paper read at 3

o'clock this afternoon, and as that time has not arrived we better take up the next paper on the program in the interim. The next paper on the program is in relation to "Methods of Proportioning Direct Radiation."

Mr. Mackay took the Chair and Prof. Carpenter read his paper, as named above.

Mr. Wolfe:—I move that a vote of thanks be tendered to our president for his very interesting paper.

Prof. Carpenter:—I am going to object to a vote of thanks to a member on general principles. I think it is the duty of every member of the society to do what little he can. If we are going to begin passing votes of thanks to members we are going to have a great big load on our shoulders. If there is anything of interest in this paper I hope it will do you good, and if there is anything in error I hope it will be criticised. It is merely presented as the result of a single experiment which substantiates some early ones and nothing more.

Mr. Wolfe:—I did not make that motion with the intention of offering a mere compliment. There is information in that paper which we all need and that is useful, and I move again that a vote of thanks of this society be tendered to the president.

Mr. Cary:—I feel with Mr. Wolfe that Prof. Carpenter has given us a very valuable paper, but I think that the motion proposed would establish a precedent which does not exist in other societies. The American Society of Mechanical Engineers does not extend votes of thanks to its members for contributing papers, though it does to a non-member, and I do not think we can do better than follow the example of the older societies, though I agree with Mr. Wolfe in the sentiment his motion expresses.

Mr. Barron:—I agree perfectly with the two gentlemen in the opinion they have expressed of Prof. Carpenter, but this matter is entirely out of order and I raise the point of order.

Mr. Harvey:—I think every one appreciates Prof. Carpenter's efforts in getting up this paper. But I do not think it would be a good plan to adopt such a motion as the one proposed.

The Chairman (Mr. Mackay):—I will settle the question by refusing to entertain the motion.

The discussion of Prof. Carpenter's paper was then taken up.

Mr. Quay:—I should like to make a motion at the proper time that our discussion of papers or topics be limited to one speech of five minutes each and that the discussion be confined to the topic or paper under consideration.

Mr. Barron:—I do not think that is in order. I prepared a discussion here and I may not be able to finish it in five minutes, although I read fast. It may take six minutes.

The Chairman:—I rather think at this time that the motion is out of order. We are under the question of discussing a certain paper. Unless the members think differently, I should like to suspend discussion on this paper for the present, as we now have Mr. Baldwin here, and we have agreed to give him the floor at three o'clock to read his paper, and if the members do not object I would ask him to do that, and I would ask Prof. Carpenter to take the chair.

Prof. Carpenter returned to the chair and said, "Gentlemen, I have the pleasure of introducing Mr. Wm. J. Baldwin." Mr. Baldwin then read his paper on "Separation of Oil and Grease from Exhaust Steam."

The President:—The next paper on the program is that by Prof. Kinealy on "Determining the Volume of Air Passing through a Register Per Minute." Before taking up that paper I wish to make an announcement. Mr. Bolton's paper is desired for special reasons to come at 8 o'clock to-morrow evening, and I wish to make the announcement now, in order that if any persons especially desire to hear that paper they may make arrangements to be here. The acting secretary will please read Prof. Kinealy's paper.

Mr. Wadsworth then read Prof. Kinealy's paper.

Following the discussion of this paper the president read the following letter:

Baltimore, Md., Jan. 25, 1897.

"To the Secretary of the American
Society of Heating and Ventilating Engineers:

"This certifies that Francis H. Waters, engineer of the Department of Buildings, has been appointed an official delegate to the meeting of the Society of Heating and Ventilating Engineers.

(Signed) "ALEXANDER HOPER, Mayor."

We are glad, Mr. Waters, to make you known to the society and we hope that you will meet and become acquainted with all the engineers in attendance and take part in the proceedings.

This, perhaps, has finished as much of the program as we should take up to-day in the way of papers. There are, however, very many topics for discussion. We can take up the topics for discussion, or we can adjourn, at the desire of the society. It is now 5 P. M., a little before our usual time for adjournment. The acting secretary wishes me to announce that those who desire can obtain ballots and the necessary envelopes for voting at his desk.

Mr. Wolfe:—May I ask one question for information? I cannot get it through my mind yet how I can vote twice. I have voted and I do not want to vote again.

The President:—If no change is desired there is no need of voting again. The first topic for discussion is as follows: "Can oil or gas fuel be used to advantage in heating dwellings?" Who has an opinion on the subject?

There was some topical discussion and then the president announced the following committees: "For the committee to consider the recommendations of the president and the various standing committees I would appoint J. J. Blackmore, S. A. Jellett, D. M. Quay; for the committee in regard to the resolutions relating to the death of John J. Hogan I would appoint Mr. H. J. Barron, Mr. J. A. Fish, Mr. W. M. Mackay. It would seem to me that we should also have a committee on resolutions in relation to the death of our lamented secretary, Mr. Hart.

Mr. Harvey:—I move that the same committee prepare both sets of resolutions.

The President:—I was going to suggest that the board of managers and council, as he was a member of the board of managers, be made a special committee in the case of the secretary, if that is agreeable.

Mr. Barron:—I make that as a motion, Mr. President. (Carried.)

Mr. Jellett:—Mr. President, you read my name on one of the committees. As that committee will report on Thursday morning I think it will be well to substitute some one else, as it is necessary that I should go back to Philadelphia to-morrow afternoon.

The President:—I would suggest, then, the name of William McMannis.

Mr. Quay:—Would it be in order to suggest topics for discussion not on the program? If so, there are two topics I should like to suggest.

The President:—I think it would be proper to suggest topics for discussion.

Mr. Quay:—One is, What should be the relative sizes of the steam and the return risers in a 2-pipe low pressure system? The other is, What is the proper velocity of steam in the pipes of a low pressure steam heating system?

The President:—My attention has been called to the fact that in the naming of one of the committees I have left off a member of the board of managers who should be on the committee, and I will rename the committee to report on recommendations in president's address and reports of board of managers and council, as follows:

Mr. J. J. Blackmore, Mr. William McMannis, Mr. H. J. Barron, and Mr. D. M. Quay.

Mr. Barron:—In regard to the committee to attend Mr. Hart's funeral, I am going over there, and I should like to go over with any member or any number of members who may be going. I think it only right that some of us should be there. There are a good many, no doubt, who cannot do it, but there are a number here I think who, like myself can be there this evening. Although Mr. Hart lived a number of years in New York he comes from another place. He practically gave the best part of his life to this society.

The President:—I think it is certainly desirable that as many should go as possibly can.

Mr. Jellett:—Can we agree on an hour and place of meeting, so that all who can go may start together?

Mr. Barron:—I propose that those who are going meet here at seven o'clock this evening.

Mr. Mackay:—I was going to make a motion that as many of the officers of the society as can will go as officers of the society.

The President:—Why could not all the officers go?

Mr. Mackay:—Certainly, and as many of the members as possible.

The President:—Mr. Mackay makes the motion that as many officers and members go as possible, as members of the society and not as individuals.

The motion was carried and the meeting adjourned until the following day at 2 P. M.

## AFTERNOON SESSION, SECOND DAY.

The meeting was called to order by President Carpenter, on Wednesday, at 2.15 P. M.

The President:—The session had some unfinished business before it which I think we better take up before proceeding to literary work. Is the report of the committee on uniform contract and specifications ready?

Mr. Kenrick:—I will say, in the absence of my colleagues, that the committee held a protracted session this forenoon in Mr. Blackmore's office, and the committee will be ready to report to-morrow morning, Mr. Jellett having been obliged to return to Philadelphia on the one o'clock train.

The President:—Then we will make that the special order for to-morrow morning. Is the committee on standards ready to report? No member of that committee seems to be present, so we will pass that for the time being. Is the committee on tests ready to report?

Mr. Cary:—I am sorry to say that the committee on tests have very little to report. No appropriation has been set aside by the society for conducting tests. The committee at the last meeting requested any members who have made tests to call the attention of the committee to their work, but no communication of that kind has been received. We should be glad to receive any suggestions from members. I think, until the society is in a position to appropriate funds for the carrying on of tests, that the committee had better be discharged.

On motion of Mr. Kenrick, it was agreed that the report of the committee be received and the committee continued.

The President:—I announced yesterday, and I wish that every member present might take special notice of that announcement, that the time for voting for officers of the society must close at 3 o'clock this afternoon, in order that the tellers may proceed with their work. The secretary, in case any one has not voted, has the necessary blanks and envelopes at his desk, and I would advise all who vote, to do so in accordance with the former rule laid down. It may not be possible to count the votes, unless the votes are made regularly, as laid down in the constitution. Are there any special reports of committees? If there are no special reports of committees, it will be in order to proceed with the regular program. The next paper on the program was made a special order for 8 P. M. this evening, by special arrangement with Mr. Bolton. The next paper on the program is, "Arrangement of Mains in Hot Water Heating Apparatus," by W. M. Mackay.

Mr. Mackay presented his paper, following the discussion of which Prof. Carpenter read his paper on the "Relative Efficiency of Ventilating by a Chimney and by a Fan."

The discussion on this paper was followed by a consideration of the topics.

The President:—We have half an hour left in the afternoon session. The second topic is now open for discussion. What is the best method of piping or connecting radiators in a hot water system to produce uniform results on a plant with long or extended mains?

No discussion.

The President:—It is understood, I believe, that where these topics are passed they will be continued on our program for another year. Topic No. 3 is: What is the highest temperaure that can be maintained in a hot air furnace without detriment to the air passing through it?

The President:—If there is no farther discussion on this subject, I would call the attention of the members to the program for this even-

ing, and then to the fact that it is time for recess until the evening session. If we are to have the evening session promptly, we ought to adjourn promptly and on time. The program this evening will be the paper by Mr. Bolton on the subject of "Circulation of Steam for Heating Purposes at or Below the Pressure of the Atmosphere." We shall also have this evening, previous to the paper, the report of the tellers on the election, and then we will take up the next question on the topics for discussion. The paper by Prof. Denton will be taken up to-morrow afternoon at 3 o'clock. There has been some delay in getting that paper from the printer. To-morrow forenoon there is some very important business which must be attended to by the society; the report of the committee on legislation and of the committee on standards and of the committee on recommendations made by the president and other committees with respect to changes in the constitution. A motion for a recess is now in order. (Motion made and carried.)

EVENING SESSION, SECOND DAY.

The meeting was called to order on Wednesday evening at 8.30 and the president announced that the first business of the session would be the report of the tellers.

Mr. Kenrick:—Mr. President and Gentlemen: The committee appointed to assort and count the ballots beg leave to report as follows: Total number of votes cast, 58, of which five were discarded on account of not complying with the constitution. The result is as follows: For president, W. M. Mackay, 39; D. M. Quay, 9; J. A. Langdon, 4; R. C. Carpenter, 1; for first vice-president, H. D. Crane, 23; D. M. Quay, 22; Henry Adams, 5; W. F. Wolfe, 1; blank, 2; for second vice-president, Henry Adams, 31; B. H. Carpenter, 19; T. J. Waters, 1; blank, 2; for third vice-president, A. E. Kenrick, 29; Samuel Burns, 15; C. B. J. Snyder, 6; blank, 3; for secretary, L. H. Hart, 48; W. O. Steele, 3; blank, 2; for treasurer, J. A. Goodrich, 47; W. A. Russell, 5; blank, 1; for board of managers, R. C. Carpenter, 41; S. A. Jellett, 37; W. F. Wolfe, 28; W. S. Hadaway, 26; E. P. Bates, 25; F. A. Williams, 24; for council, A. A. Cryer, 32; Wm. McMannis, 32; B. F. Stangland, 30; Jas. Mackay, 30; John A. Fish, 28; C. C. Lincoln, 27; W. H. Hill, 20; A. A. Hunting, 20; J. D. Hibbard, 19; C. F. Gessert, 16; blank, 11; discarded, 2. As a result of the election, you have elected: President, W. M. Mackay, New York; first vice-president, H. D. Crane, Cincinnati, O.; second vice-president, Henry Adams, Washington, D. C.; third vice-president, A. E. Kenrick, Brookline, Mass.; secretary, L. H. Hart, New York (deceased after vote was cast); treasurer, J. A. Goodrich, New York; board of mana-

gers, R. C. Carpenter, Ithaca, N. Y.; S. A. Jellett, Philadelphia; W. F. Wolfe, Boston, Mass.; W. S. Hadaway, New York; E. P. Bates, Syracuse, N. Y.; council, A. A. Cryer, Wm. McMannis, B. F. Stangland, of New York; James Mackay, Chicago; J. A. Fish, Boston.

Following the announcement of the tellers, Mr. Bolton read his paper on "Circulation of Steam for Heating Purposes at or Below the Pressure of the Atmosphere."

Mr. Barron:—Mr. President, there are a number of well-known heating and ventilating engineers here to-night who are not members of this society. I would make a motion that the council invite them to take part in this discussion. We should like to hear from those who are not members as well as from those who are. (Motion carried.)

The Chairman (W. M. Mackay):—I would request those who are not members to kindly announce their names when the rise to speak.

The paper was then discussed by the members.

Mr. Stangland:—I move that the society tender to Mr. Bolton a vote of thanks for his very interesting paper.

The motion was seconded by Mr. Cary and carried.

On motion of Mr. Harvey the meeting then adjourned until the following day.

## MORNING SESSION, THIRD DAY.

The meeting was called to order by Vice-President Quay at 11:10 A.M. on Thursday.

The report of the committee on uniform contract and specifications being called for, Mr. Jellett, the chairman of the committee, said:

Your committee has given careful thought to the subject referred to it and has worked out what to it seems a good form of contract, and the conditions governing the specifications. The decision reached was that it was not possible to put all the conditions that govern the work done under a contract into the contract itself. We think that a mistake is made in making the contract too elaborate. We therefore have taken many of the clauses that frequently are put into contracts and put them in as general conditions governing specifications, rather than the contract, and we have simplified the contract itself very much. We believe that the shortest contract it is possible to draw is legally the strongest contract, and also the most equitable contract all around. We, therefore, have shortened it to what, if printed, would be less than one page. I will read you the outline of the contract itself:

## CONTRACT.

THIS AGREEMENT entered into this..............day of..........
A. D. 189 , by and between...........................of the state of
................., party of the first part, and.........................
of the state of...................., party of the second part,

WITNESSETH, that for and in consideration of the payments and covenants herein mentioned, to be made and performed by the party of the second part, the said party of the first part doth hereby agree and covenant to furnish all materials and apparatus for, and to erect and finish, all work called for in specification prepared by.........................
................ dated ..................189 for......................
......................, to be erected in building ......................
............... street, ................. city, .......... state.

The whole of said work to be erected and constructed in conformity with the specifications above referred to, and plans prepared by ..........
.............. and numbered ...................... bearing date of
...................... accompanying the same. Said plans and specifications being hereunto attached, and are understood as forming part of this agreement. The work called for by these plans and specifications is to be erected under the direction and supervision of....................., architect or engineer for the owners.

In consideration of the faithful performance of the aforesaid covenants and agreements entered into by the party of the first part, the said party of the second part hereby covenants and agrees to pay to the said party of the first part the total sum of .................................. dollars, lawful money of the United States in installments as follows:...........
......................... shall be paid when the.....................

.......................................................................

.......................................................................

.......................................................................

Thirty days after the entire system is erected it shall be examined and tested, and if found to conform to the said plans and specifications, the final balance of ................................ dollars shall be paid.

Before receiving this final payment the party of the first part shall furnish to the said party of the second part a full release of liens, as called for under "general conditions" of the specifications.

IT IS ALSO MUTUALLY COVENANTED AND AGREED UPON, by the parties hereto, that no payment made, except the final one, shall be held as an admission by the party of the second part that this contract, or any part thereof, has been faithfully complied with, or that any detail of the work has been properly performed, in case the facts shall be otherwise.

IN WITNESS WHEREOF, the said parties have hereunto set their hands and seals the day and year above written.

Signed, sealed and :
delivered in the :
presence of :

PENALTY.—Supplementary clause that may or may not be made part of contract.

The party of the first part agrees to complete the work covered by this contract, on or before...........of...............189 . Should any

delay occur beyond the said.............189 , through negligence of the said party of the first part, or any of his or their sub-contractors, a penalty of $............ per day for each legal working day shall be paid by the said party of the first part to the party of the second part as liquidated damages for non-fulfillment of contract as to time. No other sum shall be recoverable for breach of contract to finish by the time named, saving this penalty, and only upon the conditions prescribed.

The party of the first part agrees to furnish to the party of the second part, before receiving any payment on this contract, a bond in the sum of .......................................... with ...................... ...................... as sureties for the faithful performance of this contract, said bond to be returned to the party of the first part within........ .................. after completion of work.

## UNIFORM CONDITIONS GOVERNING SPECIFICATIONS, FOR

..................

To be erected in building to be located on..............street ........ ..........town, ........................... owner, .................... ................ architect.

1. The following drawings accompany this specification and form part thereof. They are numbered as follows and are dated.................... 189 .

### GENERAL DESCRIPTION.

2. The work required by this specification includes all................

...........................................................................

.................................hereinafter specified and required for

...........................................................................

the building furnished and erected in accordance with the accompanying plans.

### QUALIFICATION OF BIDDERS.

3. Bidders on this work must be responsible parties, regularly and practically engaged in the business of...................................... and known to possess ample facilities for doing the work. They will be required to give, if asked for, satisfactory security for the faithful performance of their contract. They must carefully examine the drawings and specifications, when bidding, and if any change is deemed necessary in the details of the specification, or in the lay-out on the plans, to enable them to comply with the requirements of this specification, they must promptly notify the owners, engineers, or architects, at the time of making their proposal. Failing to so notify, the owner and his architect or engineer will consider that the plans and specifications, as drawn, will, in the judgment of the bidder, meet the requirements asked for.

### CHARACTER OF MATERIAL TO BE USED AND MANNER IN WHICH WORK IS TO BE DONE.

4. All material used throughout must be of the best of their respective kinds, where not distinctly specified as to character or manufacture, and

material used will be subject to the inspection and approval of the architect, or superintending engineer.

The entire work provided for in this specification is to be constructed and finished in every part in a good, substantial, workmanlike manner, according to the accompanying drawings and this specification, to the full intent and meaning of the same, and everything necessary for the proper execution of the plans and drawings, whether the same may be herein definitely specified or not, or indicated on the plans referred to, is to be done and finished in a manner corresponding with the rest of the work, as well and as faithfully as though the same were herein distinctly described and specially provided for.

NOTE. The foregoing clause is intended to refer particularly to the smaller details necessary for a workmanlike job and not usually specified. If any serious omission is noted on plans or in specification, it is expected that bidders will call attention to it, as noted under "qualification of bidders."

Every part of the work is to be executed under the direction of the architect or his superintending engineer, and all questions relating to the intent and meaning of the plans, drawings and specifications, or as to the kind or quality or material and work required thereby, shall be referred to the architect, or his engineer, for decision. In case of dispute, the matter shall be referred to arbitration, as noted hereafter.

The architect or his engineer shall have full power at any time during the progress of the work to reject any material which is not of the character required by this specification. They will also have the power to cause any defective or unsafe work to be taken down and altered at the cost of the contractor.

NEGLECT TO PROSECUTE WORK.

5. It must be understood that should the contractor refuse, neglect, or from any cause fail to prosecute the work with a force of men and supply material sufficient for the completion of the work within the time specified in the agreement, or should he fail, refuse, or neglect to construct the work in accordance with the plans, this specification and the requirements of the contract, then in such case, the owners may, after having given ........................ days' notice in writing to the contractor that such is the fact, proceed to employ the necessary workmen, overseers, and laborers, and purchase such material as may in the opinion of the owner, or his architect or engineer, be necessary to complete the work within the agreed time at such wages and prices as they may find it necessary to give; pay all indebtedness so incurred, and charge over the amount so paid to the contractor, as for so much money paid the contractor on account of his contract.

In case of disagreement as to whether or not the contractor has failed to properly prosecute his work, or has neglected or refused to construct the work in accordance with the drawings, the matter shall be referred to arbitration, as hereafter provided.

ALTERATIONS.

6. It is understood that the owners shall have the right to make any alteration, additions, or omissions of work or material, hereinafter specified, or shown on the drawings, during the progress of the construction of the work, and the same shall be agreed to by the contractor and carried into effect, without in any way violating or vitiating the contract, provided

such changes do not interfere with any of the guarantees made by the contractor. If the change asked for will affect his guarantees, it shall be his duty when called on to make the change to call attention to this in writing, and if then ordered to proceed with the work, it shall be with the distinct understanding that the contractor assumes no responsibility whatever, under the contract, for the portion of the work affected by the change.

It is also agreed that if any such changes are made the contractor shall submit an estimate of the value of same, whether an addition to the existing contract price, or a reduction from the same, and this amount shall be accepted by the owner or his architect, provided it is a fair amount (either addition or deduction) for the change in the work named.

In case of a disagreement between the owners and contractor as to the value of this work, it shall be referred to arbitration, as hereafter noted. It is also distinctly understood and agreed that the owners will pay for no extra work or materials, unless ordered by them or their architect or engineers in writing.

OPENINGS FOR PIPES.

7. In case the work to be done under this specification is in a new building to be erected, openings for pipes through main walls and chases in walls for pipes and openings for admission of boilers, tanks, etc., will be furnished by the owner of the building, but the contractor for this work must give him the sizes and position for all openings sufficiently early to have him leave them during construction, provided, however, the contract for work under this specification is awarded before building has advanced to such a point as to make it impossible for him to do so.

In case this contractor fails to give the information necessary as above, at a sufficiently early date to have these openings left during construction, then this contractor shall do all cutting necessary under the contract to complete his work and shall make good any damage to walls, plastering, or wood work caused by such cutting.

CARE OF WORK OF OTHER CONTRACTORS.

8. Contractor must use the utmost care to avoid damage to cornice, walls, flooring, wood work, or any other work in the building erected by other contractors. Any damage that can be proved to have been caused by this contractor shall be made good by him, or at his expense.

REMOVAL OF RUBBISH.

9. All refuse material that may accumulate through the operations of this contractor must be removed from time to time, as directed by the agent in charge, or on completion of the contract.

RISKS, BLAME, ETC.

10. Contractor is to assume all risks and bear all loss occasioned his work by neglect or accident during the progress of the work, or from violation of district, or state ordinances, laws, or regulations, encroachments upon neighbors, loss by fire, or from any other cause.

PENALTIES.

11. There shall be no penalty assessed against the contractor for work done under this specification, except as may be agreed upon at the time of signing the contract, when the date of completion of the work and the conditions under which it is to be done shall be plainly stated.

RELEASE OF LIENS.

12. The work covered by this specification, to be constructed under any contract of which this specification will form a part, is to be delivered to

the owners, free and clear of all liens and encumbrances for any claims whatsoever that may arise under any action of the contractor, or his legal representative, under the contract made for such work.

INSURANCE.

13. The owners will insure all work and material done under contract made on this specification, for which payments have been made the contractor; but, any material or labor furnished under this contract that has not been paid for by the owner, and all tools and apparatus required by the contractor for the construction of the work shall be entirely at his own risk.

PATENT DEVICES.

14. Contractor agrees to protect and save harmless the owner against all costs, charges, and expenses for, or by reason of any claims or demands whatsoever, for the use, in connection with the work herein specified, of any patented articles or devices or system, or for any alleged infringement of patents.

BOND.

15. If required by the owners, the contractor must execute a formal bond at the time of signing the contract for an amount equal to.......... the total contract price, provided that notice of the requirement of a bond is given in the invitation for bids, on work done under this specification.

PERMITS, SURVEYS, ETC.

16. Contractor for this work must procure and pay for all permits, surveys, inspector's fees, required by the city, county, or state, for any work done under this specification, and he shall obey all laws, ordinances, and rules, especially those relating to the use and obstruction of streets, side-walks, etc., and be responsible for any failure to do so.

TEMPORARY USE OF APPARATUS.

17. In case the use of this apparatus is required for temporary heating during the construction of the building, for drying out plastering, etc., the contractor will name extra price for which he will agree to run the plant during the first winter, or for any fixed period that may be named.

The owners will supply the water and coal needed and will haul the ashes, but this contractor must furnish employees necessary to operate the system, and the plant will be entirely in his charge. He will be responsible for any damage that may happen to it or the building and its contents, through use of, or accident to, the apparatus while so run.

If temporary heat is required, involving labor of connecting radiators a second time, a charge of ...................... dollars, shall be allowed this contractor for each radiator so connected.

It is distinctly understood that during such time no other contractor, or any one representing the owners, shall in any manner interfere with the running of the apparatus.

FINAL TEST AND ACCEPTANCE.

18. There shall be a final test and examination made of all work done under this specification within thirty days after the practical completion of same (which time is assumed to be when the contractor notifies the owners that the system is ready for regular use), and the owner or his representative shall then give a formal acceptance of the plant, pro-

**vided the work is found, in all respects, to conform to these specifications and the plans accompanying same.**

**SPECIAL NOTE.**

**19. It is to be understood by the parties to any contract based upon this specification and plans referred to in same that in case of rebellion, general strike among workmen, or prevailing epidemic the party of the first part shall not be held responsible to the party of the second part for any loss that may be occasioned by reason of such rebellion, strike, or epidemic, or by delays in construction of the work over which this contractor has no control.**

**ARBITRATION.**

**20. It is agreed that in case any dispute arises between the contractor and the owner, superintendent, architect, or engineer, including disputes as to meaning of the contract or specifications, or as to the amount due, or as to the liability for any work claimed to be extra, or as to the duty of the superintendent, architect, or engineer, to approve or certify to the work, such dispute shall be referred to two arbitrators; one to be selected by the contrator, and the other to be selected by the owner, or by the architect, superintendent, or engineer, on his behalf. These two arbitrators shall have power to call in a third, and the decision of a majority shall be binding on the parties to this agreement, anything herein contained to the contrary notwithstanding.**

Mr. Jellett interpolated the following remarks during the reading of the contract:

In respect to the clause relating to penalties, he said:

The explanation of that clause is that we frequently have penalties for non-completion on time, and there have been some cases where not only was the penalty collected, but suit was entered for loss of business, loss of rents from tenants, and all sorts of contingent damages, and we have put in this clause that no other penalty is recoverable.

In reference to bonds, Mr. Jellett said:

Another bugbear that I have run across has been the delay in the return of bonds. I know of a particular case now where the board of trustees absolutely refuse to return the bond. They say: "The bond has absolutely ceased to exist by time limitation; but we will hold it in case some legal difficulties turn up, when it may be of use." The bond being given for a definite length of time, the usual understanding is that it would lapse in that length of time. In some states they tell me that a certain thing provided for, not being complied with in every particular, the bond is evidence, outside of your contract, that you agreed to do it and they hold the bond for that reason.

Mr. Jellett interpolated the following before reading the clause beginning: "Every part of the contract is to be executed under the direction of the architect."

I had a question raised the other day by a contractor. He put up

two hand dampers on boilers in such a position that you could not reach them. I asked him to put a chain there so that the dampers could be operated. He said, "it is not specified." I said, "it is the spirit of your specifications that they are to be used, is it not?" He replied, "yes." But you say they cannot be used. "Well," he said, "the chain is not specified." I said, "we do not specify that the screws shall have threads in them." Well, he took the ground that that particular thing was not specified. He afterward put up a pressure reducing valve, and I asked him where his gauge was to indicate the pressure on the light side. He said it was not specified. I said: "You cannot tell the pressure on the light side of the valve without it."

My judgment is that a number of things enter into a contract which are necessary to a good job, but if you put them all in you would finish the job before you got through with the specifications. It is fair for the owner to assume that if a gauge like that is a necessary accompaniment of a regulating valve, or if a chain is necessary to open a damper, that they will come with the work without being particularly asked for, and we have drawn the clause that way.

Before the word "alterations" Mr. Jellett said:

In drawing these conditions in the contract it has been the unanimous opinion of your committee that it would be very foolish to attempt to draw a contract that is one sided; that the owner and his representatives have rights as well as the contractor, and that a contract which is not equitable to both parties never can be enforced, and we have followed that policy all through these conditions.

Before the words "Penalties" in "There shall be no penalties," Mr. Jellett said:

Now that seems rather broad, reading in that way, but the wording of it, if you pay close attention to it, makes it a fair condition. The contractor is to bear the risk occasioned to his work. It is not the work of other people. It is his own work. He assumes a certain amount of risk. An owner cannot be called on legally to assume a risk until he has acquired ownership, and that ownership can only come by his paying the bill. So, legally, the contractor is responsible for his own work until he is prepared to bill it to the party for whom he is doing the work. Then, as to the laws and ordinances, it is proper that the contractor should comply with all ordinances about blocking up the streets, or in relation to the protection of workmen. In some States there are laws about scaffolding, and it is proper that the contractor should take care of that, because the owner is not presumed to know all the ordinances and laws affecting all the details of building construction.

Before the words "The contractor agrees," the following was interpolated:

We have drawn this clause in this way, that when the owner pays money he acquires an ownership; therefore he must insure what belongs to him. The contractor, not having billed the rest of the work, insures his own. It is a distinct division of ownership, and a distinct division of the insurance and the cost of insuring. The next is the ordinary clause on patent devices.

The following was interpolated before the words "Permitting surveys, etc., section 16:"

The reason for that is, you frequently find a specification without any reference to a bond whatever. You make a bid, they award you the contract, and ask for a bond. Now a bond costs money. The trust company wants one per cent for giving the bond. I know of a case a short time ago where some work was done and a bond of $32,500 was asked, and for which the contractor was compelled to pay $325. It was just as much an item of cost as the boilers or pipes that went in that job.

The following was interpolated before the words "Final test and acceptance:"

Now that is a new clause. It came, to a great extent, through my own experience. I found a number of cases where owners had taken the apparatus and run it, sometimes with the consent of the contractor and sometimes without. If anything happens to it, the contractor is responsible. That is not fair. In all the specifications that I have been drawing for some time I have required that the owner shall furnish coal and water, but that the contractor shall take into his estimate the cost of running the apparatus. I have two or three buildings in operation now in which it is being done. The owners furnish the coal, the contractors run their own apparatus, and it is to their interest to see that the apparatus is taken care of.

The following was interpolated after the clause relating to the closing of the contract:

Now there should be a definite time for the closing of your contract. We have had that question come up in a number of forms. I have in mind a building which was finished last September. They started to use the apparatus at once. They put their own men in charge of it, took it into their possession, although they had not made the final payment. A little later on, a dynamo was wrecked through improper handling by the assistant engineer. He short circuited one machine and knocked it off its foundations. The chairman of the board of trustees said: "Go ahead and have the damage repaired, and we will discuss the responsibility afterwards." I said,

"No, sir. We will discuss the responsibility right now. The evidence is here." "Well," he says, "as we have not finally paid for this plant, we have not finally accepted it, and you are responsible for it anyhow." I said, "All right. I will take all the valves off the engines at once. I will disconnect those dynamos, and take the valves off the engine at once. If it belongs to me, then you have no right to use it." That put him in a different position at once. I said, "I will not put up an apparatus, turn it over to you for your benefit, and assume responsibility for your employes." One of the committee turned to me and said, "I understand that the men we put here to run this plant were put here with your approval and consent." I said, "No, I was not consulted." Then he said, "We have no case against you. If you had approved the selection of these men, that would be a different matter, but as you have not you are certainly free from any responsibility for this accident." They passed a resolution that they would accept the responsibility for the accident, and ordered me to go ahead and fix it. These questions will come up, particularly when a job is dragged out eternally. You will find that the building is finished, except one or two rooms, which, for some reason, they do not want finished, and six months afterwards they will raise a question: They will say, "Your work is not finished." This clause was drawn for that particular reason. There is no reason why a job should not be examined within thirty days after it is completed, as within thirty years, that I know of.

On concluding the reading of the specifications, Mr. Jellett said:

That is simply a broad, clear arbitration clause, and the man who will not agree to arbitrate a difference is a man you do not want to make a contract with. It does not necessarily follow that all those conditions shall go with every specification. But we have considered all the questions that are liable to arise under a contract or specification. We have made up a series of clauses, and they more properly belong, in the judgment of your committee, with the specification than with the contract. The contract should be that one party agrees to do a certain amount of work for the other party, and the other party agrees to pay him a certain amount for it, and if there is a time limit, that is included also. That is all that is needed in the contract. Your committee think that the better way to handle this subject would be that the new committee to be appointed should take this matter into consideration and confer with a committee of the National Association of Master Steam and Hot Water Fitters, and also request a conference with the National Institute of Architects. The Institute of Architects have an agreement with the Association of Builders, but as it applies particularly to building to a very large ex-

tent it does not fit our work; and as the tendency at the present time is to separate the heating and ventilating from the general contract, it is to the interest of all parties to have an equitable contract that they can all agree upon, and your committee ask that the new committee to be appointed take the matter up in this way and confer with the Master Steam Fitters' Association and the National Institute of Architects.

Mr. Wolfe:—There is a matter I have had the misfortune to meet a good many times; that is, in municipal contracts they advertise and say that bids will be received up to a certain time, according to the plans and specifications at such a place. You will find invariably in those specifications a clause that the specifications must be strictly adhered to, and they make their own terms, and you cannot change a thing. Well, it is a jug-handled contract, of course. This is only a question of strength. Are we strong enough to say that we have a right to say something about when we are going to be paid, how our apparatus is going to be used, and who is going to be responsible for any carelessness in the matter, and how the results are to be obtained, etc. It is not right when we finish a building, say in July, and the specification demands a full winter's test, that we should not be paid the money due us until next summer. Our bond ought to cover that.

The Chairman:—The committee recommend that the new comthink, to have a motion made to do something with the report of the committee before we discuss it.

Mr. Barron:—Mr. Chairman, I move that the report be received, and that it have, as far as it goes, the approval of this society. I believe this is in conjunction with the Master Steam and Hot Water Fitters—our committee acting with them. I move that the report be received, and that it have our approval.

The Chairman:—The committee recommend that the new committee confer with a committee of the National Association of Master Steam and Hot Water Fitters, and also with the National Institute of Architects, as I understand, to get a specification to which we all agree. Would you include that in your motion?

Mr. Barron:—Yes, I should like to very much.

Mr. Wolfe:—I should like to amend that because I think the committee has given so much study to this matter that it can do better work than a new committee. A new committee would have to go all over the work that this committee has gone over. The prester than a new committee. I would move that the present committee be continued.

Mr. Barron:—Can we not incorporate that in the motion—that it include the continuance of the old committee?

Mr. Jellett:—That could not be done, because the new president has the appointment of committees.

The Chairman:—The president, I understand, has the appointment of committees, but the society could request that the same committtee be appointed.

Mr. Barron:—I think before anything is done finally the matter should be submitted to high legal talent.

Mr. Jellett:—Some of it has already been submitted.

Mr. Connolly:—If this resolution is adopted, will it cut off all discussion on any particular clause? Would it not be better to have a little discussion on it before it is adopted?

The Chairman:—The way the motion is made would finally dispose of it.

Mr. Connolly:—Don't you think there should be a little discussion on it?

The Chairman:—That is what I was asking for.

Mr. Connolly:—Discussion now being in order there is one point I should like to refer to in regard to the temporary heat clause. It is not a criticism at all of Mr. Jellett's contract, but he said that the owner was to furnish coal and water, and the heating contractor, labor. I would object to that, because any man that you put in charge of an apparatus is responsible for it, and he is really running it under extraordinary conditions; in place of glass in the windows there may be muslin or nothing. There is all sorts of trouble, and I would naturally think you would incorporate the labor part of it in with the coal and water, and if it is run for the benefit of the carpenter, mason, or builder, or any one else, let them assume the responsibility and do not put it upon the heating contractor. He has figured on the work under ordinary conditions. Now here is something excessive, and the placing of a man there to take charge of the apparatus, the owner furnishing the coal and water, I think, really, that the heating contractor has all the responsibility. That is one thing I notice and should like to hear explained.

Mr. Barron:—I wanted to hear from you, Mr. Chairman (D. M. Quay), in regard to the practice in Chicago. I would say that the general practice here is that the owner pays for everything and he also pays for any alterations made necessary. The understanding here is that the whole expense is put on the owner.

Mr. Wolfe:—In our part of the country, if it is a furnace job, we forbid building fires unless a written guarantee is given that the apparatus will be turned back to us in as good form as when delivered except for the ordinary wear and tear, that does not amount to anything. In steam work we have been in the habit of naming a price

of so much a day for which we would furnish a competent fireman to run the apparatus or that they must assume their own responsibility for the apparatus, and that where they fire it themselves it must be considered as an acceptance of the apparatus.

Mr. Jellett:—I would answer Mr. Connolly's criticism by saying he has criticised from the contractor's standpoint. The specification has been considered both from the owner's and the contractor's point of view, and the result arrived at is one that has been worked out in practice, and has worked out very satisfactorily. There is a legal reason for doing it as well. In the first place the ownership remains in the contractor until he has built the plant. Now he may say to the owner, you can take this apparatus of mine, and run it, but you must turn it back to me in good condition. Now, assume that he does so; nine times out of ten there will be a question coming up that will be a mighty troublesome one. Mr. Connolly also states that the contractor is running under extraordinary conditions. I do not agree with him, because the conditions are made at the time of the building. He estimates for a man in whom he has confidence. The questions that frequently arise on work between owners and contractors on such matters are hard to dispose of.

We have taken this clause and have studied it from both sides. The builder wants heat. The owner will turn around to the contractor and—assuming that there are no conditions agreed on—will say, "We want to get heat in that building." The contractor will say, "Well, there is a plant; you will be responsible for it." The owner will say, "I don't know where to get a good man." Nine times out of ten he asks the contractor to recommend the man. The contractor assumes that he is the owner's man, but he has got his recommendation, and he falls back on the contractor. Now, there are very few owners who would take a plant of that kind, and would assume responsibility for it. There is a loophole somewhere in the agreement. It is true they do not often come into court, but if they do a good many contractors find they have agreements on their hand that do not hold. In taking this case the contractor is in a position where he could put his own man in charge, a man he has confidence in. He can estimate for his wages, and there is a distinct agreement that no one shall interfere with him in the running of the apparatus. The only objection in putting the coal on the owner is this: We have had architects say: "Why do not the contractors furnish the coal?" I say the contractor has to guess at the amount of coal because he does not know what the winter is going to be or what heat will have to be generated. There is only one man benefiting by this arrangement, viz., the owner. Therefore, as the owner is the

man to be benefited, why should the other man take the chances? He can estimate the wages of the man day and night for many months, but he cannot estimate the amount of coal. You buy the coal that is necessary to give you the results that you want. That clause has been pretty carefully studied, and it is an equitable clause all around. We think it is a much better clause than putting the responsibility on the owner.

Mr. Quay:—There is a question in regard to the responsibility and cost of running an apparatus. It is more than the man you furnish, as there is a certain amount of responsibility that some one has to assume. If the contractor is going to assume it he should figure it in his estimate, also the cost of insurance.

Mr. Jellett:—Yes, it is intended that he shall estimate for any responsibility.

Mr. Quay:—There is another point I think I should like to criticise and that is the insurance clause—how much the owner is responsible for. I think it states he is responsible for the amount he has paid. I think that should be 10 or 15 per cent more, because the owner only pays 85 or 90 per cent of the cost as the work progressses, and the contractor should not be responsible for that 15 per cent which is held back on the contract, because it really belongs to the owner. I think I should like to have that clause explained in such a way that it would cover the full amount of the cost. In some of our specifications we have an insurance clause to the effect that the owner is responsible for the material in place, and of course the contractor would only be paid for 85 per cent of that. The custom in Chicago varies; often the contractor is responsible for the apparatus and is paid for the expense of operating it by the owner; sometimes the whole expense and sometimes only the expense of coal and water and oil and such things, and at other times the owner takes the plant in his charge and agrees to return it in good condition to the contractor. As Mr. Jellett has said, we are considering this from the engineer's standpoint, and I think the way he has it arranged in the report is about as well as it could be arranged.

Mr. Jellett:—On the queston of insurance, in answer to Mr. Quay's observation, the percentage retained varies very considerably in different sections, but the equitable division remains the same. It does not make any difference if the owner has retained 15 per cent on the contract—he does not own that 15 per cent of material. He has legally an ownership only of what he pays for. No man can own anything he has not paid for, and usually when you have 85 per cent payments you get them on monthly statements of the architect and you do not bill your work until your contract is

completed. You send in your statement of so much work done on account, but that statement is not recognized in law as a bill. Therefore the owner is making an arrangement with you by which he gives you each month a certain amount of money on account; that is all. You do not lose any ownership in anything that has not been paid for at all, and I think that legally it is the shortest cut to an equitable solution to have the owner assume the responsibility for insurance for what he has paid for and what he really owns, and the contractor for what still belongs to him. Now it is not difficult to take care of your insurance on a contract, and on everything except some very few fire proof buildings we always carry insurance, not only on our work and material, but we carry insurance on our tools and on our drawings, because the loss of a set of drawings or anything of that kind would throw you back in your work. That question of insurance was taken up and studied from all sides. It was taken up with the idea of the owner carrying it all and with the idea of the contractor carrying it all, or of a division. But when that division comes there is generally a row, and we thought we would avoid the row and make it definite.

Mr. Barron:—I hope we have now reached the final disposition of this matter as far as this society is concerned. If the Master Steam Fitters and Architects and Builders will recognize these contracts it will be of great service to us.

Mr. Wolfe:—It may have been brought up previous to my coming in, but I should like to ask if there is anything there that would make such a specification applicable to municipal work, or is this simply between the owner and the architect and the contractor?

Mr. Jellett:—It covers all the points of issue in a specification.

Mr. Wolfe:—Does it cover that advertisement which says plans can be found in room so and so in the city hall and which tie you up hand and foot?

Mr. Jellett:—Your committee cannot draw a specification to prevent a man signing a contract he has no business to sign.

Mr. Wolfe:—The point is if we can combine here in this society and with the Association of Master Steam Fitters and the Institute of Architects and say to them, "Gentlemen, we do not care to bid on specifications like these," I am perfectly willing to do that, but I do not want any one else to go in and make a bid.

Mr. Jellett:—I have frequently done that. I did that the other day with the Bell Telephone Company on a contract that was one sided. I flatly told them that I would not sign a contract under such a specification and agreement.

Mr. Wolfe:—The specifications are not absolutely wrong, you

know. We sign a contract and we do not know just when the building is going to be started or when we can begin our work or when we shall finish it. Suppose we finish up a job in April. Under their specification they say, "Before the final payment shall be made, it must have a full winter's trial." Now our final payment is a fraction of the bond we have to give. But under the specification they ignore the bond and say, "We cannot give you any money until this has had a winter's trial." That means that we have just one year's money lying idle.

Mr. Jellett:—Those are questions that we feel it is simply impossible to cover in our contract and specification, because you find that municipal contracts vary greatly in different sections of the country. I do not think we can do anything at all to regulate those contracts, but quietly push this contract in everywhere. In the first place, if a man makes a definite set of plans and specifications he has no right to ask you for a guarantee beyond the character of your work and material. He has no right to ask you for a guarantee of results. I make a great many plans and specifications and I never ask a man to guarantee 70 degrees at zero or anything else. I ask him to put in radiating surface and certain sizes of pipes and blowers, etc. If he does that and does it properly he is entitled to his money whether it works right or not.

Mr. Wolfe:—I have not found that the municipal people are bashful in asking us to guarantee a lot of stuff that we know will not work right.

Mr. Barron's motion that the report be received and that as far as it goes it have the approval of the society and that the new committee confer with the committee of the National Association of Master Steam and Hot Water Fitters and with the National Institute of Architects was put and carried.

The Chairman:—Next is the report of the committee on standards.

Mr. Barron:—The committee on standards have nothing further to report than their report at the last meeting. I simply ask that the last report be received as their report for the present and the committee continued or discharged, at the pleasure of the society.

Mr. Wolfe:—I move that the report be accepted and placed on file. (Carried.)

The Chairman:—We have two distinguished gentlemen with us to-day, Mr. Louis Schaeffer, of Antwerp, Belgium, and Mr. Gurney, of Toronto, Canada. I wish to introduce these gentlemen to the society and to extend to them the privilege of the floor. We should be glad to hear from them at any time on any question. We will now have the final report of the committee on compulsory legislation.

Mr. Mackay:—I would state, Mr. Chairman and Gentlemen, that in compliance with the resolution that was passed here the committee met and formulated an act. After they had completed their work another form of act was handed to them. I will read the one that they suggested first and the other one later.

A SUGGESTION FOR AN ACT PETITIONED FOR BY THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, TO CAUSE PROPER SANITARY PROVISIONS, PROPER VENTILATION, AND PROTECTION FROM FIRE IN PUBLIC BUILDINGS AND SCHOOLHOUSES.

Sect. 1: Every public building and every schoolhouse shall be kept in a cleanly state and free from effluvia arising from any drain, privy, or other nuisance, and shall be provided with a sufficient numberof proper water closets, earth closets, or privies for the reasonable use of the persons admitted to such public building or of the pupils attending such schoolhouse.

Sect. 2: Every public building and every schoolhouse shall be ventilated in such a proper manner that the air shall not become so exhausted as to be injurious to the health of the persons present therein. The provisions of this section and the preceding section shall be enforced by the inspection department of the state board of health.

Sect. 3: Whenever it shall appear to the state board of health that further or different sanitary provisions or means of ventilation are required in any public building or schoolhouse in order to conform to the requirements of this act, and that the same can be provided without incurring unreasonable expense, such state board of health may issue a written order to the proper person or authority, directing such sanitary provisions or means of ventilation to be provided, and they shall thereupon be provided in accordance with such order by the public authority, corporation, or person having charge of, owning, or leasing such public building or schoolhouse.

Sect. 4: No wooden flue or air duct for heating or ventilating purposes shall hereafter be placed in any public building or schoolhouse, and no pipe for conveying hot air or steam in such building shall be placed or shall remain placed nearer than one inch to any wood work, unless protected to the satisfaction of said inspector by suitable guards or casings of incombustible material.

Sect. 5: Any school committee, public officer, corporation or person neglecting for four weeks after the receipt of an order from the state board of health, as provided in section three, to provide the

sanitary provisions or means of ventilation required thereby, shall be punished by fine not exceeding one hundred dollars.

Sect. 6: The expression "public building" used in this act means any building or premises used as a place of public entertainment, instruction, resort, or assemblage. The expression "schoolhouse" means any building or premises in which public or private intruction is afforded to not less than ten pupils at one time.

Sect. 7: This act shall take effect upon its passage.

RESOLUTION adopted at the annual meeting of the American Society of Heating and Ventilating Engineers, January, 1897.

W. M. MACKAY, Chairman,
A. E. KENRICK,
B. HAROLD CARPENTER, Sec.

The Chairman:—I think the second one can come up under discussion on a motion to adopt the committee's report. If there is no objection a motion will be entertained. What shall we do with the committee's report?

Mr. Barron:—I move that we adopt the report as read. (Motion seconded.)

Mr. Jellett:—What is the nature of the other act? Is it an alternate act?

Mr. Mackay:—I should call it an enlarged act.

Mr. Jellett:—Is it more definite than the one we have heard?

Mr. Mackay:—It gives maximums and minimums, I believe.

The Chairman:—If there is no objection we will hear the paper read.

Mr. Mackay read the following:

## AN ACT

### TO SECURE PROPER SANITARY CONDITIONS AND PROPER VENTILATION IN PUBLIC BUILDINGS AND SCHOOLHOUSES.

The people of the state of New York, represented in senate and assembly, do enact as follows:

Sect. 1.—Every public building and every schoolhouse shall be kept in a cleanly state and free from effluvia arising from any drain, cess-pool, privy, or other nuisance, and shall be provided with a sufficient number of proper water closets, earth closets, or privies for the reasonable use of persons admitted to such building or attending such schoolhouse.

Sect. 2:—Every public building and every schoolhouse shall be ventilated in such a manner that the quantity of foul or vitiated air exhausted or removed shall be positive and independent of atmospheric changes and shall not be less than 20 cubic feet per minute for each person, and the quantity of fresh air admitted shall

not be less than 20 cubic feet per minute for each person that such public building or schoolhouse can accommodate. The provisions of this act shall be enforced in each village, city, town, or county by the board of health thereof. It is made the duty of such boards of health, within one year from and after the passage of this act, to inspect all the buildings then in use within the meaning of this act, and thereafter to inspect every six months all buildings which shall be applied to the uses herein recited. It is further made the duty of any such board of health, on application in writing of any one interested for an inspection of any public building or schoolhouse, to make an inspection within a reasonable time, not exceeding one month after the receipt of such written application, and in every case such inspection shall include the determination of the quantities of air actually removed and introduced, and their sufficiency under this act.

Sect. 3:—Whenever it shall appear to the proper board of health, upon inspection of any public building or schoolhouse, that the sanitary provisions or means of ventilation thereof are insufficient to conform to the requirements of this act, such board of health shall issue a written order to the proper person or authority, directing such sanitary provisions or means of ventilation to be supplied, and the same shall thereupon be supplied by the public authority, corporation, or person having charge of, owning, or leasing such public building or schoolhouse.

Sect. 4:—Any public officer, corporation, or person neglecting for one month after the receipt of a written order from the proper board of health, as hereinbefore provided, to supply the sanitary provisions or means of ventilation required thereby, shall be punished by a fine of one hundred dollars. If any board of school trustees shall for a like period of time fail to comply with the requirements of such written order from the proper board of health, each member of such board of trustees shall be punished by a fine of one hundred dollars; provided, however, that in any case wherein the board of health is satisfied that such failure to comply is unavoidable, and that the trustees, public officer, corporation, or person responsible, is in good faith preparing to comply with such order, this penalty may be remitted.

Sect. 5:—Whenever it shall appear to the proper board of health that a written order, given under the fourth section hereof, has not been obeyed within one month after its delivery to the propr person or authority, such board of health shall have power, and it is hereby made its duty, to prohibit the use of such public building or schoolhouse until the requirements of such order are complied with, it being provided that such action shall not be taken by such board of health

if it shall be satisfied that the failure to comply is unavoidable, and that the trustees, public officer, corporation, or person responsible is in good faith preparing to comply with the requirements of the order.

Sect. 6:—The expression "public building" used in this act shall include any public building or premises used as a place of public entertainment, instruction, resort, or assemblage. The expression "schoolhouse" shall mean any public building or premises in which instruction is afforded to not less than ten pupils at one time.

Sect. 7:—This act shall take effect upon its ratification.

Mr. Jellett:—I think there are some parts of that bill which are more definite than the other and to be preferred to the other on that account. It is a very difficult thing to draw an act of that kind which will apply in every state. The outline I think is there in pretty good shape. There is one thing there; I notice that you fine each member of a village school board $100 for failure to carry out instructions. He may not have money to carry them out and he may not have $100 to pay the fine with. There ought to be some reasonable protection for those local schools or places of that kind, because it may mean the complete alteration of a building, and it is hardly fair to elect a man a school director and say in four weeks, "You have got to tear this down," and he says, "We have not the money." And you say, "We will fine you $100." There ought to be some provision to take care of a case of that kind. But the question of the minimum amount of air to be supplied and exhausted I think is a step in the right direction. I think that everything left to the discretion of the inspector amounts to nothing. One inspector may become the czar of his neighborhood and another may be so easy that he will allow anything to be done. It is like putting the word "satisfaction" in a contract. I think myself that this latter act, if gone over, could really make a very good outline of what is wanted and then it could be put in proper shape for enforcement. It says a man shall be fined $100, but it does not say how the fine should be collected. Those are legal questions that naturally come up.

The Chairman:—Would the committee be willing to take the two acts and make up one from them and report again, or what shall we do in the matter? Of course the motion is to adopt the committee's report—the first act read.

Mr. Kenrick:—I should like to reply to Mr. Jellett. The bill says, "When in their judgment the health of the pupils is endangered." That matter has been gone over pretty thoroughly in the state of Massachusetts. It has been discussed pro and con; also

the subject of referring the matter to the local boards of health. Wherever you refer that matter to a local board of health nothing ever will be accomplished, because the members of the local board of health are afraid of their constituency and will make no movement towards the enforcement of the law. Thirty cubic feet of fresh air per pupil was established in Massachusetts, after a series of tests covering a period of something like two years, by a board of experts and a board of physicians making tests and establishing beyond any question about how many cubic feet of air had to be provided to keep the carbon dioxide below eight or ten parts per 10,000, and that was the result they arrived at—that nothing less than 30 cubic feet of fresh air per pupil would accomplish the result. The committee have the idea in this recommendation that the state boards of health, in all probability, would consult with the authorities of Massachusetts and find out what results were obtained there and probably take that as a precedent to follow.

Mr. Wolfe:—I coincide with Mr. Kenrick's idea. I have seen the thing work. We will take a high school, as I am more conversant with the matter of high schools. Most of them hold sessions so many days in the year; otherwise they do not draw their money from the state. Now if a high school is found to be entirely wrong the committee say, "You must make changes." But they add "Of course we understand that you cannot make them now. Make them during the summer vacation. We give you four, five or six months, as the case may be, to find out what is the best thing to do." This $100 fine is not supposed to be paid by anybody but the man who accepts the responsibility of supervising the condition of the schools in his district. It is not only right to fine him $100 but it is right to hang him if he does not do it. I believe that. This is an old school committee argument: "Almost every man that owns a horse goes down to the stable at least once a week to see how his horse is being taken care of; now how many of you men go to the school once a year to see how your children are being taken care of?" It is just so with every man in this country, and why? We go to the polls and vote for certain men or women, as the case may be, in whose judgment and ability we have confidence to see that our children are well cared for, that their health is looked after, and that the sanitary conditions are right, not only as to their health, but also in the line of decency. Now if these men neglect that, why don't they pay $100? They have no right to accept the office unless they accept the responsibility. But that is not what I was going to talk about when I got up. The bill that was last read is what we want. There is a lot of human nature about things of this sort. You probably all

have noticed that a politician who is up for election is a great deal more willing to shake hands with you the day before than the day after he is elected. It has been my experience in dealing with these people that if I attempt to tell them what they ought to do they assume that the majority of the constituents in their county or state, or whatever it may be, ought to be better able to judge what ought to be done than I am. Otherwise they would have sent me there. If we lay out a bill and ask a man to get up on the floor and say, "This is from the American Society of Heating and Ventilating Engineers and I want to do this," how many votes would he pull out of it? Mighty few. If, on the other hand, he gets up and says, "I have looked about the schools in my district and I believe that something ought to be done on this question of ventilation of school buildings and preserving the life and health of our children and of our teachers —when we touch the question of the children's lives and the children's health, we are getting nearer to the man than you can get in any other way—I have been working at this thing a good while." If I went in to sell a man an apparatus to heat his house or anything of that kind I would get a very cold shoulder if I could not convince him that I had something that would affect the health or well being or better education, or make a stronger man of his child than he would be if he did not listen to what I had to say. That has been my experience. No greater opportunity occurs to a man in his lifetime, as a member of the legislature, or of congress, or of a senate, for getting up on the floor and making a speech that will make him so strong in his community as a speech on that line. He will not only have the men that vote, but he will have the women, too, that make the men vote. If we lay down a given law that does not afford that man latitude, if we make a suggestion, he is not bound to quote us, he can present a bill as we say it must be—we can pray, petition, or request that he introduce a bill something on these lines. I do not believe that we as a society, or any man here as an individual, is prepared to go on record to-day as to any quantity of air as a minimum. Twenty feet might be enough under certain conditions. But let us leave that to the discretion of the people. There is a good deal of human nature in getting these bills through and getting what we want, and making the other fellow think that he did it. If my memory serves me, the first clause of the suggested bill which came to the committee after they had prepared what they did prepare, has a beginning that would probably make it a little smoother. That might be incorporated in the other bill. First we want that this bill shall be put straight, in due form. If it goes to a board of health their reputation as public officers is at stake. If we say specifically in

that bill 20 cubic feet, and they give 20 cubic feet, it might be enough or it might not, but if we leave it to them to make their own position, they will do this—unless they are different from any officers I have ever seen—they will get up in the front rank and won't be satisfied to be behind any one. They will take testimony from the people that they have confidence in. They will base their judgment, not on the testimony of any one man, but on all data they have been able to get, and it leaves it discretionary with them, not as a law, but as a rule of the department to issue an order, something like form 83 issued by the Massachusetts authorities, and you can be just as sure as you sit here, or at least I am, that if we leave out the figures as to what they must do, that the figures they will call for will be more than 20 cubic feet of air per capita as a minimum. I believe that to be true. I believe that the bill will go through and I believe it affords an opportunity to the members of the different legislative bodies that they will not only be glad to avail themselves of, but that they will fight among themselves as to the one who shall have the opportunity to father the bill, because, as I tell you, it makes them not only strong with the men, but they get the women back of them who have quite an influence.

Mr. Gurney (Toronto):—I like one clause of this bill where it deals with metal to be used in ducts. I think, however, in schoolhouses provision should be made for cleaning the ducts, as it is very important, in cases where scarlet fever has been developed—you know currents of air come in through as well as pass out of these ducts—that there should be every means for keeping them clean. I think this society would do a great service to the country if they would condemn in the strongest language the practice of using furred floors as a means of conducting foul air from a room. In the West this means has been used, and we know that it is practically impossible to clean an exhaust duct of that kind, aside altogether from the danger from fire. I should like to see a recommendation from the society that all exhaust ducts be made of metal and in such a way that they could be cleaned.

The Chairman:—The time is up for closing; in fact, it is past. Is there any further discussion? The motion is to adopt the report as read—that is, the first act that was read. Some have suggested that the ideas of the other bill be embodied in the first one.

Mr. Andrus:—I make a motion that the two bills as read be returned to the committee, let them take such parts of them as would make a more complete bill than either, and that they report a final bill later on. I offer this as an amendment to the original motion.

Mr. Wolfe:—Won't that put us back a year?

Mr. Jellett:—The committee have heard the sense of the meeting and can act on it.

Mr. Wolfe:—If we are going to do this thing we might just as well get at it. We do not know what the next legislature is going to be.

Mr. Barron:—I hope Mr. Andrus will withdraw that motion. The committee have given an immense amount of work to this matter and we want to make a final adjustment of it. Their judgment is that the first bill is feasible and practical. It would take us a year, I believe, to harmonize the two bills. I want to do just what the committee want to have done. I am satisfied they have given calm consideration to this matter.

The motion to accept the report of the committee as read was adopted, after which the president announced that the close of the session was at hand, and adjournment was taken until 2 P. M.

### AFTERNOON SESSION, THIRD DAY.

Vice-President Quay called the meeting to order at 2:10 P. M. on Thursday afternoon.

The Chairman:—The constitution says that the installation of officers shall be at the last session. I suppose there is no objection tohaving that the first order of business now. If there is no objection we will have the installation of officers first, provided they are all here. Are the new officers all present? It seems that the officers elect are not all present and we will have to postpone this for a little while for that reason. I have overlooked one thing on the program —the reports of special committees. Are there any special committees to report that have not reported? The first committee to report will be the committee to recommend changes in the constitution as suggested by the president, board of managers, and council. Is that committee ready to report?

Mr. Barron:—Mr. Blackmore has the report. It is not quite ready.

The Chairman:—The next will be the discussion of topics unless we consent to hear the paper on "A Comparative Test of Two Centrifugal Fans." The time for this to be read was set for three o'clock to-day. Mr. Cary cannot stay very long and I understand he wishes to discuss this paper. I am a little undecided in my mind whether it can be taken up now or not, on account of its having been announced for three o'clock; and quite a number of members are not here. I will leave that with the society.

Mr. Barron:—I move that we commence to read this paper at half-past two instead of three o'clock, as previously ordered. (Motion carried.)

The Chairman:—Prof. Carpenter has suggested that in place of

some of the topics on the program two or three others that have been presented be taken up and discussed. If there is no objection to this, the first of three topics will be, "What is the proper velocity of flow of steam in the pipes of a low pressure heating system?" Has any one anything to say on this question? If not, we will pass to the rest. I will ask Mr. Mackay to take the chair.

Mr. W. M. Mackay took the chair while Mr. Quay and others discussed this and other topics.

Mr. Quay:—The time of half-past two was set for the presentation of Mr. Denton's paper. I would call attention to the fact that that time has now come.

Mr. Albert A. Cary read the paper by Prof. J. E. Denton on "A Comparative Test of Two Centrifugal Fans," which was freely discussed.

The Chairman (Mr. Quay):—If there is no further discussion on this paper, we will have the installation of officers. (Chairman read names of newly elected officers.) I will ask Mr. Mackay to take the chair as president of the society. Gentlemen of the convention, I introduce you to your new president, Mr. W. M. Mackay. (Applause.)

President Mackay, on taking the chair, said:

Gentlemen:—I thank you for the honor you have conferred on me in electing me to the highest office in the society. I shall endeavor to do all that I can to further its interests in every way possible. To accomplish this I shall require the assistance of every member of the society. I shall thank every one for any suggestion he can send to me or to the board of managers that will further the interests of the society, and I will say that such suggestions will always receive attention.

At this time I will announce the committees.

On compulsory legislation: B. Harold Carpenter, W. F. Wolfe, S. A. Jellett, A. Harvey, H. M. Swetland.

On uniform contract and specification: S. A. Jellett, D. M. Quay, J. J. Blackmore, A. E. Kenrick, A. C. Mott.

On standards: J. H. Kinealy, H. J. Barron, William McMannis.

On tests: A. A. Cary, B. F. Stangland, Henry Adams.

Nominating committee: H. J. Barron, Frank W. Foster, John Gormly, T. J. Waters, Homer Addams.

I would ask the old board of managers and also the new board of managers to meet immediately after the close of this session. I would say, too, that the retiring board of managers and the retiring council together form the committee on resolutions on the death of our late secretary, and they should meet at that time.

Mr. Barron:—I have here the report of the committee on the revision of the constitution, which should go on file. It is as follows:

Your committee on the revision of the constitution beg to report that they consider the following changes as being advisable:

Article 2, section 2; to have the age limit struck out; section 3, to have the age limit struck out.

Article 5, section 1; to add to this section the words "And they shall hold a regular meeting every two months." Section 2; to add to this section the following: They shall have full charge of all matters relating to the literary or scientific parts of the society's work and shall hold meetings every two months or oftener if the affairs of the society so require.

Article 10; to be changed to read "This constitution may be amended at any regular meeting of the society, the proposed amendment having been submitted in writing to the secretary, who shall send a copy of it to all the members at least 60 days previous to the date of the regular meeting."

Mr. Jellett:—There is one question I wanted to ask in connection with the constitution. There is a very flat contradiction in our constitution that ought to be corrected at the same time. In the last paragraph but one of Article 6 it says: "No member or associate in arrears since the last annual meeting shall be allowed to vote until said arrears shall have been paid." That is an acknowledgment that an associate has a right to vote. Now in the clause on membership, Section 6, it says: "All members, honorary members, juniors, and associates shall be equally entitled to the privilege of membership, except that honorary members, juniors, and associates shall not be entitled to vote." It says there flatly that they shall not be entitled to vote. Later on it says that if their dues are paid they may vote.

Mr. Barron:—I suggest that Mr. Jellett put that in writing so that it can be taken up at our next meeting. This did not come before our committee because we did not have time to do very much work. I am going to put on file an amendment that the president and secretary shall be a part of the council, as well as of the board of managers, as at present. That can also be taken up at a future session. I hand that in simply as a member of the society, outside of the work of the committee on recommendations.

The report, on motion duly seconded, was adopted and the committee continued.

The President:—There is one matter I should like to bring up here, and that is to announce the vacancy caused by the death of our secretary and to ask the society what is their intention in connection with it.

Mr. Andrus:—I move that the vacancy be filled by the board of managers until our next election. (Carried.)

The President:—Is there any other business to bring before the society at this time, or shall we take up the topics? The next one is Topic No. 4: What is the value of radiated heat in the fire box of a boiler?

After discussing this and other topics the president announced:

There is one point which has not been brought before the society that was recommended in the president's address, that is, Shall we have a semi-annual meeting? Does any member wish to express himself on this subject?

Mr. Quay:—Mr. Chairman, in talking with our late lamented secretary, Mr. Hart, about two weeks ago, he said he thought it would be a good idea to have an informal semi-annual meeting, and at that time have a few papers, meeting simply for a day. He said it was being talked of by some of the members. I do not know whether it might have been dropped on account of his illness. Some of the other members may know about it. I should think that an arrangement of that kind might be beneficial to the society.

Mr. Stangland:—I think it is unwise with our present numbers to attempt a summer meeting, as the summer would probably be the time selected. If we had a thousand members scattered over the country we could have a meeting in Chicago, or St. Louis, or Boston. But I think it is unwise to attempt such a movement for the next two or three years at least.

Mr. Jellett:—I move that the semi-annual meeting be dispensed with for this year. (Seconded.)

Mr. Barron:—I do not know but that may be wise, but Prof. Carpenter did not think so. He said that we must have it. That is the way he put it. We need a meeting every six months, he said. That was in connection with his idea of increasing the membership to 500. There are two things we need. We need a large increase in membership and more funds, and a large increase in the membership will give us more funds, of course, and make us more useful. As Prof. Carpenter is not here, I want simply to put his ideas before the society, so that the members can act as they think best. Mr. Kent makes the suggestion that the matter should be left to the joint action of the council or the board of managers, so I will make an amendment to Mr. Jellett's motion, if he will accept it, that this matter be referred to the board of managers with power to act. (Motion carried.)

Following the discussion of various topics, Mr. Stangland moved that adjournment be taken. The motion was duly seconded and carried, the president again calling attention to the meeting of the old and new boards of managers and councils to be held after adjournment.

## XXIV.

# PRESIDENT'S ADDRESS.

BY PROF. R. C. CARPENTER, ITHACA, N. Y.

(President of the Society, 1896 to 1897.)

Gentlemen and members of the American Society of Heating and Ventilating Engineers: It gives me great pleasure to welcome you at this, our third annual meeting, and I trust that you will find much in the proceedings to interest and aid you in future work. The past year has been one of general business depression, and in a certain measure large enterprises in the peculiar line of our profession, as well as in other directions, have been to a certain extent suspended, or at least not prosecuted with usual vigor. There has been, however, no serious depression, and while the amount and quality of works in our peculiar field may have been somewhat less than in the most prosperous years of the past, there has not been that complete business depression which has characterized and affected many of the industries. Our engineering society, considering the character of the business of the country, has doubtless prospered and can now certainly be said to have established its right to be recognized as one of the great engineering societies of this country. It has established a strong foundation for a broad and noble society and is now in position to commence active work for the benefit of the science and art of heating and ventilation, and it should have and doubtless will have the confidence and support of every desirable person engaged in this work in this country.

Time does not permit me to discuss many recent improvements in appliances or in methods of heating and ventilation, but I will briefly mention the important work which is being done in two fields. One field is the application of mechanical systems of ventilation to the art of ventilating and heating. Already papers have been presented before the society as to the details used in these various arts, and no member of the society needs to be informed of the special methods in use. It may be said briefly that this admirable system, which introduces constantly a uniform amount of air and warms or tempers that air as required to produce a uniform temperature,

seems in many respects the ideal system. Each one of the last three years has served almost to mark an era, so rapid has been the development of ventilating and heating by this system, and unless one be intimately connected with the special industry to which reference has been made, it is very difficult indeed to appreciate the vast strides and improvements in this direction.

The president must also call your attention to the great and recent improvements which have been made in the art of temperature regulation. We must all admit, I think, that in order to crown with perfection the art of constructing heating and ventilating apparatus there must be means provided which shall automatically regulate the supply of heat to meet the demands for uniform temperature. This art is not a new one; on the contrary the needs of temperature regulation were appreciated more than a century ago and a temperature regulator was constructed by Bonemain in 1777, which utilized the expansion of metals to directly open or shut the dampers governing the supply of heat. Various other forms have been designed from time to time, and inventors years ago recognized the fact that the amount of motion to be obtained by the direct expansion of liquids or solids was insufficient to give satisfactory results. This led to the substitution of motors so arranged that the expansion of the thermostat or its contraction served merely to start or stop the motor, and this in turn moved the valve to regulate the supply of heat. For motive power electricity was used as early as 1835, clock work wound by hand also at a very early time. The use of other motive forces, as, for instance, water under pressure, steam, or compressed air were also early suggested, if not actually applied. Later the use of double motors in which the electric current put into operation some other motive force, which in turn opened or closed the main valve, has been successfully applied. The latest development, however, is one in which compressed air is used as the motive force, the thermostat serving to admit or close off the supply of compressed air, and this in turn acts upon the main valve which governs the supply of heat in such a manner as to keep the temperature uniform. The mere philosophy of the system of temperature regulation is in every case simple, but the mechanism required for its practical application must be well constructed and made of the best materials; practically it has been found that workmen for this art required an education and a practical training, which required years of time, and consequently it is only within the last few years that the art of constructing this apparatus in such a manner that it would be sensitive and reliable under all conditions can be said to have been in existence. It is now possible, however, to add to the other ap-

paratus required for heating and ventilation temperature regulators which will move positively and certainly, which will maintain the temperature within one degree of any desired point, regardless of the exterior temperature, and which will, after the various rooms of the building are brought to the required temperature, act upon the dampers of the heater. In a similar way the amount of ventilation is also governed. The temperature regulators in all their perfection are the products of a great amount of skill, and at the present time those of good character are necessarily expensive, but during the next few years these improvements will doubtless be lessened in price, as well as improved in quality, following the natural law of the production and development of any very important invention.

I could also refer you to many other great improvements, as, for instance, the heating by hot water with forced circulation and those which have been made in relation to steam heating with less than atmospheric pressure. These, however, I may assume that you are familiar with and will merely say there is no engineering profession, no mechanical trade, that is more prolific in inventions than that relating to the profession we represent, which profession, being intended to promote both the health and comfort of the people, is of very great importance.

Our society has seen fit to appoint a committee on compulsory legislation and it may seem to many who are not members of our society that this committee is appointed to forward the selfish interests of its own members. To correct such an impression I wish to state from the fact that the objects of our profession are to provide, first, comfortable rooms and, second, healthy rooms, that we do have the right, which I believe will be recognized, of urging the passage of such laws as will require good ventilation, since without good ventilation good health is not possible. I take it that we do not have any right to ask legislation that any provision shall be made with reference to heating, since that is a matter which affects personal comfort rather than health, and no law should intervene to fix the standard of comfort for any individual. With respect to ventilation, however, it is a different question, since it is one which vitally affects our health, but does not in turn affect our sense of comfort. That is, we are not sensible whether we have good ventilation or poor ventilation and are unaware, until our health is dangerously affected, that the ventilation is otherwise than good. For these reasons, especially for public buildings, we have the right to insist that legislation shall be passed which shall protect the health of the public. For this reason the committee on legislation occupies a very important position, and it should be their duty

to lay before the society the draft of laws for this purpose, which should be introduced in every legislature in the country. One state, that of Massachusetts, has a law which, although not perfect, is a very great improvement and advance in the interests of public health. The law of Massachusetts has been in practical operation now for several years and the results have generally been satisfactory in every respect. I think it the duty of every member of our society to do what he can to secure the enactment of a similar law in every state in the Union.

We have also a committee on uniform contract and specifications, and we shall expect to hear from that committee many valuable things with reference to the commercial part of our business. There is no reason to adduce arguments for the necessity of such a committee. To secure uniformity in methods of work and in business competition, a form of uniform contract and specification is desirable.

We have also a committee on standards whose duties are to study the various questions in relation to heating and ventilation and to present to the society, as a result of this study, what, in their opinion, may serve as minimum or maximum standards of excellence, both as to the amount of heat, the amount of ventilation, and the materials to be used. Their duty would also be to consider the adoption of any standards recommended by our membership.

We also have a committee on tests who should report to the society results of any important tests with reference to heating and ventilation. This committee has for its general duties the same as that which is charged to each and every member of the society, and for this reason I have questioned in my own mind whether the continuance of this committee can be of any special value to the society and whether it would not be better to appoint special committees as occasion required, both for standards and for tests, instead of having general standing committees in these special fields.

In the practical application of the provisions of the constitution during the past year, there has been some difference of opinion and this, of course, indicates a lack of clearness in the wording. I would suggest that such changes be proposed as will render all questions of this nature impossible to raise hereafter.

The desirable changes, it seems to me, would relate to, first, a clearer statement of the duties of the board of managers and of the council. I think the council should be given entire charge and responsibility of the candidates and program. I would also recommend two meetings each year.

In regard to membership I should advise cutting out the age

limit and also of extending the field sufficiently as to make at least 2,000 persons in this country eligible for membership. The strict wording of our requirements for membership would probably limit us to less than 500 who are capable of joining. As only about one-half of those who are capable of joining would care to join, our present requirements are such as to keep the society exceedingly small. The field of utility of a national society would certainly be very restricted unless it could have at least 500 or 1,000 members, and for that reason I should like to see the wording of article 2, section 2, so changed as to admit managers of manufacturing establishments and editors of heating and ventilating journals to full membership. Both of these classes of men are in many senses engineers; they are greatly interested in the art of heating and ventilation; they are in nearly every case men of exceptional ability in their especial lines. In accordance with my idea we need these men, not as associate members, but as active members, with every privilege of voting and holding office. I feel that with such men we shall have broadened our field and shall have secured the co-operation of the best workers in the field of heating and ventilation and without these men I feel that our society is working in too restricted a field to ever reach the influential position which it should by virtue of its objects attain.

# XXV.

## METHODS OF PROPORTIONING DIRECT RADIATION.

BY R. C. CARPENTER, ITHACA, N. Y.

(Member of the Society.)

As a result of inquiry I find that the methods employed by heating engineers for proportioning the amount of radiation necessary for warming a building vary greatly in different localities and also with different engineers in the same locality. The methods in use are nearly as numerous as are the engineers using them. A number of engineers, probably more than half, take the radiating surface as some proportion of the cubic contents of the room to be warmed and without any regard to the amount of heat which is required and which can be furnished. All who use the latter method of calculation combine with it a method of estimating which is founded on experience or judgment and by means of which they add to or subtract from the result obtained from calculation such an amount as in their opinion should warm the building properly. This system is at best a refined method of guess work and tends to explain why different engineers give estimates which are so widely different for the heating of the same building. Without considering this matter further I will briefly call the attention of the society to methods which have been proposed in the past and to a modified method resulting from experiment which I have checked by use of several years and believe it to be at least worthy the trial of all heating engineers.

It is evident that the heat which is required for warming must be sufficient to supply the loss of heat from the walls, windows, ceiling, and floor, and also sufficient to warm all the air which enters in various ways and is used for ventilation. The first and perhaps the only experiments of any value for determining the loss of heat from the walls of buildings were made by Prof. Eugene Péclet of Paris from 1835 to 1845. The results of these experiments were formulated and put in convenient form for application. Péclet's methods were translated into English by Thomas Box in his work on Heat and in that way have been made familiar to American and English readers. The formulæ for the loss of heat from walls and windows

as given by Péclet and endorsed by Box are very elaborate and consider the separate losses due to radiation and convection. The convection losses are, however, considered only for still air and consequently are not applicable without a large and very uncertain correction.

These formulæ indicate a loss by convection which decrease with the height. This change is sensible when the difference of temperature is great, but of little or no importance when the temperature is small. The results of the investigation, then, indicate that the amount of heat given off per square foot of exposed area would be less as the height is greater. The laws stated by Péclet are undoubtedly correct for still air and the coefficients which he gives seem to agree very well with those obtained on later tests.

I will not take the time of the society with formulæ and coefficients given by Péclet, since they are available in a recent book by the by the writer* and can be consulted at leisure. The coefficients are doubtless of sufficient interest to merit republication and are given as follows in the book referred to.

Loss of Heat from Windows.—The values which Péclet found for glass reduced to English measures, were as follows‡:

LOSS PER SQUARE FOOT PER DEGREE DIFFERENCE OF TEMPERATURE FAHR. PER HOUR FOR WINDOWS.

| Height of Window. | 3 ft. 3 in. | 6 ft. 7 in. | 10 ft. | 13 ft. 3 in. | 16 ft. 3 in. |
|---|---|---|---|---|---|
| Loss in B.T.U. per sq. ft. per degree difference of temperature. | 0.98 | 0.945 | 0.93 | 0.92 | 0.91 |

For multiple glass the above numbers are to be multiplied by the following coefficients:

$$\text{Double } \frac{2}{3}, \quad \text{Triple } \frac{1}{2}, \quad \text{Quadruple } \frac{2}{5}, \quad \text{n layers } \frac{2}{1+n}$$

Mr. Alfred R. Wolff, M.E., in a recent pamphlet gives coefficients adopted by the German Government, as follows:

Heat transmission in B. T. U. per square foot per hour per degree difference of temperature; single window 1.09; single skylight 1.118; double window, 0.518; double skylight, 0.621. These coefficients are to be increased, as explained in the next article, for exposed buildings.

Loss of Heat from Walls of Buildings.—The loss of heat depends upon the material used; its thickness, the number of layers, the difference of temperature between outside and inside surfaces, and air exposure.

* Heating and Ventilating Buildings, New York, John Wiley & Son.

‡ The general formula which Péclet gives as expressing this loss is as follows: $m = \frac{1}{2}(T - \theta)(K + K^1)$ in which $T$ = temperature of the room, $\theta$ = temperature of the air, $K^1$ = coefficient loss for convection. $K^1$ varies with the height. $K$ is constant, and in all cases equal to 291 when the temperature is measured by a centigrade thermometer. The values of the coefficients $K$ and $K^1$ were determined by experiments.

The problem is one very difficult of theoretical solution, and we depend principally for our knowledge on the results of experiments.

The following tables were computed from formulæ given by Péclet and reduced to English measures by the writer.*

AMOUNT OF HEAT IN BRITISH THERMAL UNITS PASSING THROUGH WALLS PER SQUARE FOOT OF AREA PER DEGREE DIFFERENCE OF TEMPERATURE PER HOUR.

| Thickness Inches. | Single Wall. | | Wall with Air Space. |
|---|---|---|---|
| | Brick or Stone. | Wood. ‡ | Brick or Stone. |
| 4 | 0.43 | 0.12 | 0.36 |
| 8 | 0.37 | 0.065 | 0.30 |
| 12 | 0.32 | 0.045 | 0.25 |
| 16 | 0.28 | 0.033 | 0.21 |
| 18 | 0.26 | 0.031 | 0.19 |
| 20 | 0.25 | 0.03 | 0.18 |
| 24 | 0.24 | 0.029 | 0.17 |
| 28 | 0.22 | 0.027 | 0.15 |
| 32 | 0.21 | 0.025 | 0.13 |
| 36 | 0.20 | 0.020 | 0.12 |
| 40 | 0.18 | 0.18 | 0.10 |

Mr. Alfred R. Wolff, in a lecture before the Franklin Institute, gives coefficients for loss of heat from walls of various thicknesses, which he translated from and transformed into American units from tables prescribed by the German Government as follows:

FOR EACH SQUARE FOOT OF BRICK WALL.

| Thickness of Wall. | 4" | 8" | 12" | 16" | 20" | 24" | 28" | 32" | 36" | 40" |
|---|---|---|---|---|---|---|---|---|---|---|
| Loss of heat per sq. ft. per hour per deg. of difference of temperature.............. | 0.68 | 0.46 | 0.32 | 0.26 | 0.23 | 0.20 | 0.174 | 0.15 | 0.129 | 0.115 |

| | | |
|---|---|---|
| 1 square foot wooden beam, planked over or ceiled... | as flooring...... | K = 0.083 |
| | as ceiling....... | K = 0.104 |
| 1 square foot fire proof construction floored over...... | as flooring...... | K = 0.124 |
| | as ceiling....... | K = 0.145 |
| 1 square foot single window......................... | | K = 1.09 |
| 1 square foot single skylight....................... | | K = 1.118 |
| 1 square foot double window......................... | | K = 0.518 |
| 1 square foot double skylight....................... | | K = 0.621 |
| 1 square foot door.................................. | | K = 0.414 |

These coefficients are to be increased respectively as follows:

Ten per cent where the exposure is a northerly one and the winds are to be counted on as important factors.

Ten per cent when the building is heated during the daytime only and the location of the building is not an exposed one.

Thirty per cent when the building is heated during the daytime only and the location of the building is exposed.

Fifty per cent when the building is heated during the winter months intermittently, with long intervals (say days or weeks) of non-heating.

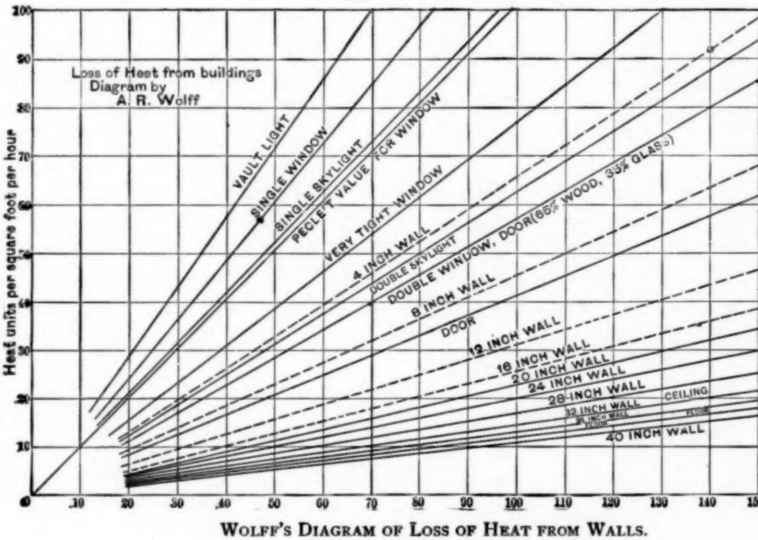
By reference to these various coefficients it is seen that the heat loss per degree difference of temperature for one square foot of glass for the ordinary window, as given by Péclet, is very nearly one heat

* $M = C\,Q\,(T-\theta) \div (2C + (Qe)$, in which $Q = K + K^1$, $e$ = thickness and $C$ = coefficient of conduction.

‡ These values apply to solid wood construction, and not a framed or built up structure.

unit, and as given by Wolff it varies with construction, but the mean value is not essentially different from that given by Péclet. The heat loss for the walls per degree difference of temperature varies slightly by the different authorities, but for a wall 16 to 20 inches thick, of brick or stone, its loss is essentially one-fourth that from the same amount of window. From these tables it is seen that for usual conditions of construction the loss in heat units per degree difference of temperature would be equal to the area of the glass plus one-fourth the wall surface expressed in square feet.

In addition to the heat which is constantly passing from a building through the walls and windows a considerable amount must be




WOLFF'S DIAGRAM OF LOSS OF HEAT FROM WALLS.

used to warm the air which enters, and this latter may be considered as a function of the cubic contents of the room.

From my own observations in the heating of residences (direct radiation) I am satisfied it is safe to assume that the air of the principal living rooms will change twice per hour, that the air of halls will change three times per hour, and that the air in the other rooms will change once per hour under ordinary conditions, and that since one heat unit will warm 55 cubic feet of air under usual conditions one degree, we shall need to supply from 1-55 to 3-55 of the cubic contents in heat units per hour. This gives us, then, a very simple expression for the heat required in B. T. U. per hour for one degree

difference of temperature. Take W as the wall surface in square feet, G the area of glass or window surface, C the cubic contents in cubic feet, n the number of times the air must be changed per hour, and h the total heat in heat units for one degree difference of temperature between the room and the surrounding space.

$$h = \left(\frac{n}{55} C + G + \frac{1}{4} W\right)$$

For the ordinary conditions of heating we are usually required to proportion the radiation so as to maintain the temperature at 70 degrees when the outside temperature is zero and, furthermore, all the portions of the house are kept so nearly at the same temperature that it is perfectly safe to consider that the heat losses on the inner or partition walls are insignificant. We can also generally disregard the ceiling loss, although in some cases it may be necessary to consider it. It is, however, seldom more than one-quarter that from the same area of exposed wall surface, since the difference of temperature between the room and the attic above is seldom more than one-third of that between the room and the exterior air and the ceiling can usually be regarded as giving an insignificant loss. It should be never neglected however unless this is known to be the fact.

Under usual circumstances, then, the total amount of heat which is to be supplied in heat units is 70 times the above quantity. The amount of heat which is supplied by one square foot of radiating surface varies somewhat with conditions of structure and use, but does not differ greatly under ordinary conditions of pressure and temperature from 280 heat units per square foot of steam heating surface and from 175 heat units from one square foot of hot water heating surface.* Dividing the formulæ given above after being multiplied by 70 by these latter numbers, we have as a result which is applicable to ordinary conditions and gives the amount of radiating surface to heat to 70 degrees in zero weather:

$$\text{For steam heating } R = \frac{1}{4}\left(\frac{n}{55} C + G + \frac{1}{4} W\right)$$

$$\text{For hot water heating } R = 0.4\left(\frac{n}{55} C + G + \frac{1}{4} W\right)$$

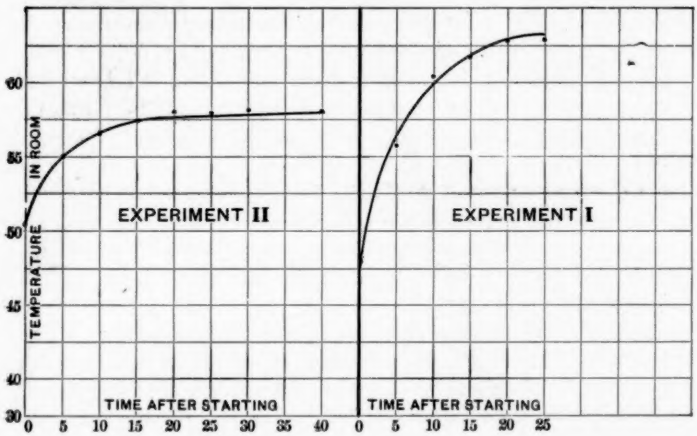
In the formulæ given above R is the square feet of radiation, W the exposed wall surface, C the cubic contents, n the number of times the air in the room changes per hour, which varies from one to three, as explained.

---

*See Radiator Tests: Heating and entiiating Buildings by the author.

In order to test the accuracy of the rule which has been stated so far as it relates to the coefficient giving the loss of heat from the walls and windows of a building the writer planned an experiment which should be conducted in a room exposed on two sides and protected on all other sides by rooms in which the temperature could be kept at such a point as to prevent any sensible flow of heat from or into the room. The walls of the room were of brick 16 inches thick and the errors, as shown by two tests, which would have been caused in applying the rule as stated above were less than one per cent and considerably less than reasonable limits of observation. The experiment in question conducted was by Mr. Albert Barnes, M. E., and the following is a report of his investigation:

The work undertaken in this experimental investigation was to verify, if possible, certain constants or coefficients of heat transmission



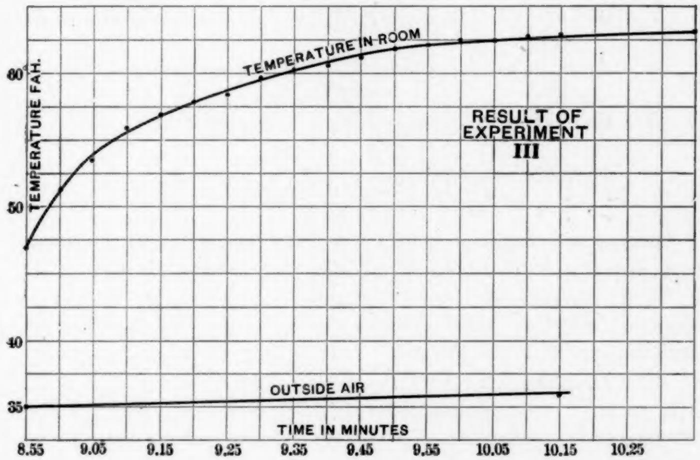

and at the same time observe how a room heats up when supplied with a low pressure steam system.

To this end a room on the second floor of the southwest corner of the Sibley Annex was fitted up with the necessary appliances. A 3-inch iron pipe having 16 square feet of heating surface was connected with the low pressure steam main through a common steam separator to insure dry steam for the experiment. A small steam gauge gave the pressure available at this point of the system. At the other end of the pipe a series of pipe fittings served to collect the condensed water which, by a suitable means, could be weighed and have its temperature taken.

The room in question had two exposed walls, respectively south

and west; the size of the room was 22 feet 8 inches long, 9 feet 10 inches wide, and 10 feet 6 inches high, and had a total wall surface of 684 square feet, or 342 square feet of exposed wall of which 96 square feet was the glass surface of the four windows. The adjacent room on the north side was heated at essentially the same rate, so that no sensible amount of heat could pass through the partition wall. The attic above was warmed and was practically elimated.

In making a run the temperature of the room was reduced very nearly to that of the outside air, then the windows were closed and the steam turned into the pipes. Every five minutes the temperature of the room was noted at four different places, the weight and temperature of the condensed water and the steam pressure were




taken, as well as the temperature of the outside air and the temperature of the adjoining rooms.

The rate of rise in temperature became less and less as time passed and at length a point was reached where a constant temperature was maintained, as will be seen by the curves plotted.

When this point of constant temperature was reached it showed that the heat given off by the steam pipe was just equal to the heat conducted from the room to the outer air through the wall. The temperatures of the room, outside air, inner rooms, condensed water, the steam pressure and weight of condensed water were now noted and the run came to an end.

Considerable difficulty was experienced in making these experiments, as they could not be undertaken when the room below was

in use as the floor would become quite hot and change the result materially, also at times when the sunlight struck the outside of the buildings the conduction was checked and the experiment brought to an end for that day.

If we let x equal the coefficient of heat transfer per degree of temperature difference between the outside and the inside air for each square foot of surface of brick wall and let y equal the same for glass; G the window area in square feet; W the exposed wall; T the difference of temperature, then the following equations result:

For the first case where the difference of temperature is 28 degrees F.

$$TGx + TWx = \text{heat loss.} \quad \text{General equation.}$$

For test II.—$28 \times 246 \times y + 28 \times 96 \times x = 4247$ B. T. U.

Error in assumed rule $\frac{91}{100}$ of one per cent.

For test III.—$27 \times 246 \times y + 27 \times 96 \times x = 4240$ B. T. U.

Error in assumed rule $\frac{32}{100}$ of one per cent.

These equations are so nearly identical that they cannot be solved with any degree of accuracy, but by substituting the values of 1 B. T. U. for each square foot of glass per degree of temperature difference and $\frac{1}{4}$ B. T. U. for the same conditions of wall surface, the equations are satisfied within 38 B. T. U. in the first case and within 13 B. T. U. in the second case.

It may also be of interest to note in this connection that the highest difference of temperature between the room and the outer air was practically the same in both cases, viz., 28 degrees F.

—DATA.—

| | |
|---|---|
| Length of room, | 22.75 ft. |
| Width of room, | 9.83 ft. |
| Height of room, | 10.50 ft. |
| Area of outside walls, | 342. sq. ft. |
| " " brick " | 246. sq. ft. |
| " " windows, | 96. sq. ft. |
| " " steam pipe, | 16. sq. ft. |
| No. of windows, | 4 |

| | RUN I. | RUN III. |
|---|---|---|
| Steam pressure, average | 2.3 lbs. | 3 lbs. |
| Duration of run, | 45 min. | 80 min. |
| Water condensed per hour, | 4.4 lbs. | 4.42 lbs. |
| Temp. of condensed water, | 212° F. | 212° F. |
| Absolute pressure, | 17 lbs. | 17.6 lbs. |
| Latent heat at this pressure, | 960.8 | 959.56 |
| Heat given off by steam pipe in B.T.U. per hr., | 4247. | 4240. |
| Temp. of outside air, | 30° F. | 36° F. |
| " " room, (max.) | 58° F | 63° F. |

TEMPERATURE.

EXPERIMENT I.

| Time. | Steam Pres. lbs. | Weight of $H_2O$. lbs. | Different points in room. (1) | (2) | (3) | (4) | Average in Room. (5) | Condensed Steam. (6) |
|---|---|---|---|---|---|---|---|---|
| 10.30 | 2.5 | .... | 58 | 45 | 39 | 50 | 49 | 188 |
| 10.35 | 2.5 | 1 | 62 | 52 | 48 | 62 | 56 | 193 |
| 10.40 | 2.5 | 1 | 66 | 56 | 54 | 66 | 60.5 | 195 |
| 10.45 | 2. | 1 | 67 | 58 | 56 | 69 | 62 | 190 |
| 10.50 | 2.5 | .94 | 68 | 60 | 58 | 71 | 63 | 190 |
| 10.00 | 2.5 | 1.25 | 70 | 60 | 60 | 74 | 68 | 180 |
| | | | EXPERIMENT II. | | | | | |
| 8.35 | 4 | .... | 52 | 48 | 48 | 54 | 50 | 212 |
| 8.40 | 2 | 1 | 56 | 49 | 56 | 59 | 55 | 212 |
| 8.45 | 1.5 | 1 | 57 | 50 | 59 | 60 | 56.5 | 208 |
| 8.50 | 1.5 | .94 | 58 | 51 | 59 | 61 | 57.5 | 204 |
| 9.05 | 2.5 | 1.62 | 58 | 51 | 58 | 63 | 58 | 195 |
| 9.20 | 3 | 1.75 | 59 | 52 | 59 | 64 | 58 | 203 |

Temperature columns 1, 2, 3, and 4 show the temperatures at different points of the room; column 5 gives the average of these, and column 6 gives the temperature of the condensed steam.

The data for experiment I is not complete, as the sun heat interfered before its completion, and that data is not considered in the results.

The same order of tabulating will be observed on the following table:

TEMPERATURE.

EXPERIMENT III.

| Time. | Steam Pres. lbs. | Weight of $H_2O$. lbs. | Different points in room. (1) | (2) | (3) | (4) | Average in Room. (5) | Condensed Steam. (6) |
|---|---|---|---|---|---|---|---|---|
| 8.55 | 6.5 | .... | 49 | 43 | 48 | 48 | 47 | 212 |
| 9.0 | 6.75 | .94 | 54 | 47 | 52 | 52 | 51.25 | 204 |
| 9.05 | 6.75 | 1 | 56 | 49 | 52 | 58 | 53.73 | 200 |
| 9.10 | 7 | 1 | 58 | 51 | 55 | 60 | 56 | 200 |
| 9.15 | 6 | 1.12 | 58 | 52 | 58 | 60 | 57 | 212 |
| 9.20 | 5.5 | .88 | 59 | 63 | 59 | 63 | 58.5 | 212 |
| 9.25 | 5 | .94 | 59 | 53 | 59 | 63 | 58.5 | 208 |
| 9.30 | 5 | 1 | 60 | 54 | 60 | 64 | 59.5 | 212 |
| 9.35 | 5 | .94 | 60 | 54 | 61 | 66 | 60.25 | 210 |
| 9.40 | 4 | .94 | 60 | 55 | 62 | 66 | 60.75 | 205 |
| 9.45 | 3.75 | .94 | 61 | 55 | 63 | 66 | 61.25 | 202 |
| 9.50 | 3.5 | 1 | 61 | 56 | 64 | 67 | 62 | 200 |
| 9.55 | 3 | .94 | 61 | 56 | 64 | 67 | 62 | 190 |
| 10. | 3 | .94 | 62 | 56 | 64 | 68 | 64.5 | 188 |
| 10.05 | 3 | .94 | 62 | 56 | 64 | 68 | 64.5 | 192 |
| 10.35 | 3 | | 65 | 59 | 68 | 70 | 65 | |

The temperature at the time of the last reading was practically constant and the experiment was brought to a close by the commencement of work in the room below.

The method which is given here will be found one easy to apply; it is of rational form in that it proportions the heating surface to the amount of heat required, and it is believed from the experiment cited and from the fact that it has been extensively used by certain en-

gineers and found to be in every case satisfactory, to be worthy of the fullest confidence as giving average values for average conditions. The method which has been outlined, but which I have not reduced to the form of rule or formula is capable of a wide application to every condition.

Considering the fact that the climatic changes involve variations in the movement of the air as well as of the wind a considerable allowance sufficient to cover such cases must be made, and it is extremely doubtful if the very elaborate rules which are given by Péclet and Box are as satisfactory as the ones stated here, those rules being especially unsatisfactory, although very elaborate so far as loss of heat from the walls are concerned, since they entirely neglect the heat required for warming the air which, in spite of the greatest precaution to make the rooms tight, will enter to a considerable amount and to an amount which is sufficient to seriously affect all other calculations.

## DISCUSSION.

J. J. Blackmore :—I should like to ask Prof. Carpenter, for the information of the society, if he has ever conducted any experiments with a view to determine how much heat is actually lost or how often the air changes in a room that has no means of inlet or outlet. It is assumed in this paper that the air is changed once, twice, or three times per hour according to the location of the room, but as accurate data is what we are after, and as the paper gives a great deal that is valuable, I thought I would raise this question with a view of bringing up a little discussion to see if some means could not be devised by which that could be determined, so that we could have accurate data from which to work.

Prof. Carpenter:—This is only approximate and I should be glad to hear the experience of members. The question Mr. Blackmore raises is an important one and one that we never have investigated. In fact, I have never seen clearly a method which could be used to measure the change of air in a room successfully. The importance of the question is very great.

Mr. Blackmore:—To advert to the same thing, there must be a definite relation between the outside temperature and the temperature of a room as to the amount of air that comes in from the outside, because we know the pressure is due directly to the difference in temperature between the inside and outside air. Then the wind, we know, has a very great influence on the changing of the amount of air in a room; and it has occurred to me that possibly experiments might be undertaken, say when the temperature was at zero

outside and the rooms at 70 degrees, to see how much air would come in at a given opening; or we might test different porous substances and so get at the matter in some way.

Mr. Barron:—The men that proportion the radiation of the country do not talk much about how they do it. There is one gentleman I know in this city who proportions over 500,000 feet a year, and I do not think you could get him to talk on this subject at all. Ten million feet are proportioned every year in this country, and I think I know the men who proportion at least one-half of that. I do not think they will ever use a scientific rule or that those who succeed them will. This paper approaches the subject from a scientific standpoint. The practical man approaches it from the standpoint of experience. The remarks that I have to make on the subject are from that standpoint, as Prof. Carpenter has given the other standpoint very thoroughly. The method of proportioning radiating surface by allowing for the loss of a certain number of heat units through exposed surfaces, due to difference between outside and inside temperatures, is the only one theoretically correct, but I am inclined to think that Mr. Bates, in his paper some years ago, defined the problem properly, that is, until you have a standard construction of building you can not have a standard rule for proportioning radiating surfaces at standard pressures. If Prof. Carpenter would tell us exactly how to account for air leakage and poor buildings generally, he would do us an invaluable service. I hardly like to say it, but this question of radiation by continual threshing does not seem to yield very satisfactory results. Would not the best way be to tabulate all the various classes of buildings and then have a coefficient or constant for each kind of building and for the various classes, good, bad, poor, indifferent, and so on? What is wanted is data or rules to meet new problems, as the old stereotyped buildings have their radiators and pipes proportioned on the average very correctly. In fact we have reached minimum proportions in pipe sizes and radiators in all ordinary classes of structures. It is possible that some one may be able to find, from time to time, something new to say on this subject, but I doubt it. I do not believe that the men of 50 years ago had much to learn on the subject or that they ever made serious mistakes. Our practice to-day is a little more accurate and as things advance it will get almost absolutely so, and I think the proportion of heating surface to be put in a hot blast stack for a heating fan is the data that is of importance to-day. I know how difficult a task Prof. Carpenter set before himself when he tried to bring forward a new or original method of proportioning radiating surface, but there may be decidedly valuable matter in this offering

on a subject that nearly every man whose business is daily to proportion radiating surface thinks has been completely exhausted and of no possible hope of anything new being said or done on it. But I remember when Prof. Carpenter's treatise on heating and ventilation came into our office; it was tossed aside after we had glanced through it—my young assistant and I—and the verdict was "nothing new." But since then we have found very valuable matter there; in fact, we have found it a storehouse of valuable data. But I do hope that this is the last paper on radiation that will be brought forward for at least five years. I think I know all the men pretty thoroughly that proportion the radiating surface used in this city, or the most of it, and they make very few mistakes, and I know they have no interest in the subject—they are like Dinah in cooking good bread—it is so simple that they wonder any one should make a fuss over it. If a man cannot proportion radiating surface with Baldwin's rule and common sense, he should make up his mind that he is worthy of a higher vocation. I have a little memorandum and if you have no objection I will read it. It is from a publication issued by the Gurney Heater Mfg. Co.: "The writer was asked the other day to account for the failure of two heating plants to effect the result sought for in their erection, viz., the heating of the buildings. In one the medium was steam, the other water. A long series of questions led to the conclusion that the respective systems had been properly constructed, and a soulution had to be sought in the buildings which could not be satisfactorily heated, and it was found while the plaster was not actually placed on the walls, the studding was so thin in both cases that the key of the plaster touched the brick and so gave a continuous conduction of heat to the outer atmosphere. Most careful engineers would hesitate to heat a building having no air cushion either in the hollow brick wall or in the opening between the brick and plaster walls, but it is just possible to be deceived, and to find that the ordinary appliances will not heat the buildings and that, additions being made, the use of fuel is extravagant and makes the contract one ever to be remembered with sorrow and disgust. This suggestion is worthy of consideration of engineers, and where orally made has called up reminiscences of similar events in the history of men who have said on more than one occasion, 'there is something in that.'" Now, that is my practical experience.

Mr. Wm. Kent:—By invitation, not being a member of the society, I am allowed, I understand, to take part in the discussion. Not being a member of the society, nor calling myself a heating and ventilating engineer, I have yet had something to do with heating

and ventilation of buildings in which I have been interested, and have called in members of the society to do the work. In one case I called for specifications and bids to heat and ventilate a building, got three or four bids and gave the contract to the highest bidder, deliberately, because he provided plans and specifications which I could understand. He told exactly where he was going to put his radiating surfaces and all about the sizes of radiators, mains, etc., and he got the contract, and the job was perfectly satisfactory. In another job with which I was connected the men were asked to furnish their own specifications and the result was we got three or four bids having no similarity to each other. Each one was based on "experience," and one man specified twice as much heating surface for a given area as another. It happened, also, that this very man who got the contract before for being the highest bidder was the highest bidder again, and the peculiar feature of his bid was that he offered less heating surface than any one else. So I took all the plans to an expert, who is one of those "scientific fellows," and asked his advice. He said that the man who had bid on the smallest amount of heating surface had bid exactly right, that is, as to the amount of heating surface, not speaking of the price. He had given sufficient heating surface, while the other men had given an entirely unnecessary amount. These other men were all "practical" men and did this from their knowledge and experience of how to heat a building, and yet one man put twice as much heating surface in as another, because his experience told him to do it. I accepted this scientific man's verdict and changed the specifications and told them all to bid on the same heating surface and we would take the risk. The result was several hundred dollars saving, because the lowest bidder—and he reduced his bid—got the contract, and the work has been entirely satisfactory.

It may be as the previous speaker says, that the heating engineers will not use this formula. If not, so much the worse for them. Their descendants certainly will either use this or some other scientific formula. To say that heating and ventilating engineers are not going to use formulæ is simply saying they are not up to the times.

In regard to Prof. Carpenter's paper, I should like to ask him a question about one of the figures on page 77—280 heat units per square foot of steam heating surface for ordinary conditions of pressure and temperature. I wish he would state definitely what these ordinary conditions of temperature and pressure are, and put the matter in the form of heat units per degree per difference of temperature. I think the form of the formula that Prof. Carpenter

has given is certainly admirable. I do not know that I have ever seen a better one. If there is anything to be changed in it in the future, it will be the co-efficient which relates to the changing of air in the room. Possibly he will modify it some day to account for the gas lights and also for the number of people in the room. I think in public buildings that will have to be considered.

Mr. Barron:—I wish to ask Mr. Kent whether, if two technical gentlemen took Prof. Carpenter's data, they would reach the same result in the proportioning of radiating surface in a building. That is, two scientific engineers working on the same rules?

Mr. Kent:—They would provided they used the same data and the same rule.

Mr. Barron:—I say using the data given in these rules. Do two men ever proportion anything the same? Do two men ever proportion the cylinders of an engine the same—in compound engines?

Mr. Kent:—Most undoubtedly. There is a very marked agreement all over the world in proportioning cylinders.

Mr. Barron:—In compound and triple expansion?

Mr. Kent:—Yes, it is almost down to rules not varying five per cent from the first.

Mr. Barron:—Do you think that is possible in proportioning radiating surfaces from your experience?

Mr. Kent:—I would say there is always some doubt about the conductivity of certain walls, and it has to be assumed or guessed at. The scientific man who has studied what walls will do is probably a little better able to determine what the conductivity will be than a man who guesses.

Mr. Barron:—You simply put up a stuffed man when you say "a man who guesses." Do you suppose a man like myself, who is proportioning radiating surface all the time, does not consider glass and walls and all that ? When you put up a stuffed man you can knock him down, but when you put up facts as they are it is not so easy. One man's business is to contract for putting in radiating surface and take the responsibility for its success or failure. The other man approaches it as a scientific engineer, like yourself, from another standpoint. We discussed the whole subject when we discussed Prof. Kinealy's paper last year, and the opinions of the practical men were all in favor of the practical method, and the opinions of the scientific men were in favor of the scientific method, and that would be the same if you discussed the subject for a million of years.

Mr. Kent:—There is no difference between the practical man and the scientific man when they see both sides of the subject. It is the

old question of the shield; one man said it was gold and the other said it was silver. It was both; gold on one side and silver on the other. The best science to-day is taking what is done in practice and finding what is known and what is only guessed at, separating the known from the unknown and putting together the known information into a form for convenient use. There is no stronger believer in experience than I am, but I also believe in science, which studies the results of experience, puts the different kinds of experience together and compares them, one with another, and thus finds out what is the truth and what is simply guess work.

Mr. Connolly:—I have listened to Mr. Kent on occasions when he has soared into the realms of empyrean on theory and have also known him to come down to terra firma in practice. He stated that the formula in regard to steam engines did not vary among scientific engineers. I have in mind an inventor, a baggage master, I think, out in Sleepy Eye, Minn., who did not pay any regard to formulas, and has succeeded in bringing out a rotary engine.

Mr. Kent:—You have not read the latest news about that?

Mr. Connolly:—I am sorry, Mr. Kent, I did not read the afternoon papers, but returning to the discussion of Prof. Carpenter's paper, he says this system is at best a refined method of guess work, and then on page 75 he states in the first line, "The problem is one very difficult of theoretical solution, and we depend principally for our knowledge on the results of experiments." Then on page 82 he speaks of the method outlined as being capable of a wide application to every condition; then further, in speaking of the rules in regard to Box and Peclet, he says that they are "very elaborate, so far as loss of heat from the walls is concerned, since they entirely neglect the heat required for warming the air." Considering these statements, I am inclined to agree with Mr. Barron as regards radiating surface, and think Mr. Barron and I could visit an architect's office, and we would vary, as practical men; also Messrs. Kent, Baldwin, and Prof. Carpenter, as theoretical men, could visit the same offices and I know they would vary. In my humble judgment empirical data or formulas based on observation are superior to assumption.

Mr. Harvey:—I should like to mention one thing in connection with Prof. Carpenter's paper that I think is worthy of consideration, viz., the distance of adjoining buildings from the one heated. I am sure that would make great difference in the actual results.

Prof. Carpenter:—There have been some questions asked with reference to this paper which, it seems to me, require explanation. In the first place, with reference to the remarks made by Mr. Barron, I thoroughly appreciate what he says and believe that I thoroughly

sympathize with the view from his standpoint, and I am very glad indeed that he has the courage of his convictions in stating what he believes. I feel, however, and I think he must feel, that while his method is no doubt in his own hands a perfect success—and I am saying this with all due deference to men who have learned these methods thoroughly and practically—it is not a method which commends itself for general use. I know, for instance, and I presume this statement is true with regard to Mr. Barron and other men who are so skilled in the methods of proportioning radiating surface for different buildings in their respective localities by the simple means of dividing the cubic contents by some number which is modified by experience and surrounding conditions, that the radiating surface is often proportioned by such a method accurately and so nicely that the results are all that could be desired, and, in fact, I may say that the work of one engineer of this class has been so admirable that I took the pains to compare the rule given in the paper with the actual surface used in numerous buildings and thus checked our scientific co-efficients with the actual results of the practice of this one man, and in nearly every case the difference was so slight as to be inappreciable. I did this, I might say, before I published the rule, because I believed it must agree with good practice in order to be correct.

In reference to the points raised by Mr. Connolly, which are very good ones indeed, I would say, first, in reference to the statement on top of page 75 of the paper,—"The problem is one very difficult of theoretical solution and we depend principally for our knowledge on the results of experiments," the statement implies that it is useless with our present knowledge to try to calculate results within a certain percentage, perhaps several per cent of average results. It is useless to try to figure closer than one per cent or, say, to one-fifth of one per cent with our present knowledge of different buildings. We have simply got to figure averages, and the co-efficients which are given in the paper give us that average as closely as possible. I might say that in all engineering work, so far as I am acquainted with it, such is the general method. For instance, in the proportioning of bridges—and that is supposed to be the most accurate of all engineering calculations—the same principles apply. To cover variations of individuals from the average they allow a "factor of safety," usually of five—some people call it a "factor of ignorance"—in order that they may apply their scientific rule with safety. The rule for heating is to be applied in the same way; that is, we cannot expect to figure from our scientific methods within certain percentages. Another thing which has struck me in the discussion and which,

it seems to me, is rather a strange one to raise in an engineering meeting, and yet perhaps it is a fair one, too, is, How can a man be an engineer and not be a practical man? That is a question that I do not understand. I do not understand, for instance, why Mr. Barron is a practical man and I am not. I have had charge of the expenditure in the last year of large sums of money in practical constructions, and yet he tells me that I am not a practical man. Now that is a distinction that I do not quite understand. Possibly it is because I am a teacher in a college that I am not practical. I do not know what other reason there is. This much is certainly true—that I have tried to get at the practical methods that were in use and I have tried to find out why such practical methods were used and have endeavored to show how the scientific methods were modified by practical use—but possibly, after all, I am not practical. (Laughter.)

Mr. Cary:—It may be out of order to make a few remarks after you have closed, but I should like to say that a good deal of distrust has arisen from the fact that young technical students after graduating and being at work, as they term it, for a year or two are making a great many mistakes. They are using technical formulas and have not the practical experience to help them out, and until they have that they are not practical men. But every practical engineer who has a scientific education applies his formulas and gets his results, but along with those formulas he applies a little co-efficient known as the co-efficient of common sense, which is attained with years of experience.

Mr. Barron:—Mr. President, I have proportioned radiation for the last ten years in my work by Baldwin's rule, using the co-efficient of common sense. This is bringing back the same discussion we had before. What I said I want to accentuate—science is only classified knowledge, and so is practical experience. Mr. Nason and all those who followed found certain things to be true from experience. The scientific investigator commences on the other side. He starts with units of heat, then he measures, and then he experiments. The bringing of those two types together produces the thoroughly practical man.

Mr. Baldwin:—In my office I have a young man, a graduate of Stevens Institute, who this morning said, "Mr. Baldwin, I have just proportioned the indirect radiators for this house, and here is a rule which calls for about 48 feet of indirect surface for a certain room. Is that sufficient? It was a small room and it was hot water surface. I looked at it and saw the contents of the room and size of flue, etc., and replied, " Yes, probaby 48 feet of surface in some forms

will do, but if we take three sections of this surface (about 16 square feet per section) I am afraid we will not get air space enough. It makes 48 feet of surface certainly, but we have only two little passages between the three sections for the passage of the air and this may not be sufficient, and I had to increase the radiator to five sections to get the flow of air I wanted.

I simply give this as an illustration that where by rule one can have some general idea of the surface he ought to use, a man who is not in our line requires experience in the use of them. This was a case where I had to nearly double the surface, not because I required it as heating surface, but to let the air through. It is necessary to have the coils or radiators sufficiently deep to warm the air to the required temperature and sufficiently great in plan between sections to let the required amount of air through. This determines the surface of coils arranged in tiers. The Sturtevant Co., the Boston Blower Co., the Buffalo Forge Co., and the American Blower Co. at Detroit, and those making heaters and radiators of pipe, fastened to headers and set in casings, understand this principle thoroughly and therefore do not proportion by an arbitrary rule.

# XXVI.

# SEPARATION OF OIL AND GREASE FROM EXHAUST STEAM.

BY WILLIAM J. BALDWIN, M.E., NEW YORK, N. Y.

(Non-member of the Society; Presented by request.)

There seems to be considerable difference of opinion as to whether grease can be effectually and entirely separated from exhaust steam. The reason, no doubt, for the difference of opinion rests entirely with those who have failed to obtain satisfactory results from grease separators, or, as they are often called, eliminators or grease extractors.

When live steam enters an engine it carries with it the oil necessary to lubricate the engine. The quantity of oil entering an engine at each stroke or revolution is, we may say, infinitesimally small, though in the aggregate it is considerable, and with some lubricators very great. It does its work, however, by maintaining the lubrication of the cylinder and piston and shows its presence and diffusion within the steam by reaching all parts of the inside of the engine, and if it is not separated manifests itself most decidedly in the boiler, when exhaust steam is used for heating purposes. No doubt much of the oil that passes through the engine is simply held in mechanical suspension within the steam, due entirely to the rapid motion of the steam through the ports and passages of the engine. It is more than probable, however, that a certain percentage of the oil carried into the engine, particularly with high pressure steam, is converted into a vapor and becomes thoroughly mixed with the steam—just the same as the vapor of any of the light oils becomes mixed with air—and it will not separate from it until its (the steam's) temperature has fallen below some certain point, that may be variously assumed, but which it is very difficult to fix and may vary with different oils.

For instance, steam at 100 pounds pressure and a temperature of 338 degrees F. will find some part of nearly all oils that it is capable of vaporizing. The percentage may be comparatively small, say not one-tenth of the whole, the remaining oil being simply minutely

divided and carried in the steam mechanically, somewhat like a spray, but never actually mixing with it. As the temperature of the steam decreases beyond the point of cut-off in the engine it is certain that some of the volatile oil that is formed at high pressure, condenses and becomes a liquid oil again as the pressure runs down, so that by the time the engine emits its steam as exhaust steam, with a temperature of about 214 degrees, it is throwing out with the exhaust steam all the oil that it carried in with it when it was high pressure steam, but in a somewhat changed form. In other words, the oil that became dissipated and broken up by the high pressure steam as it entered the engine leaves the engine again almost entirely as oil in the liquid form, such as it passed through the lubricator.

There is, however, even at this point in the process, with steam at or about 214 degrees F., some of the oil that originally entered the engine that has not as yet condensed, but is being carried away as a hot vapor of oil, while the bulk or greater part of the oil is condensed or never was vaporized and is passing out with the entrained or condensed water that the exhaust steam carries out of the cylinders and out of the pipes. The oil that is held in mechanical suspension within the steam, therefore, is held in minute globules and principally forms an oil envelope to each minute globule of condensed water. The volatile oil within the steam is a vapor like the steam itself and is quite difficult to separate from the steam until the steam itself actually condenses and leaves no medium for the support of the vapor of oil.

As before intimated, however, the quantity of vapor of oil is always changing with the pressure and temperature of the steam, being greater in quantity at high pressures and changing to liquid oil as the pressure decreases.

In the separation of oil, therefore, from exhaust steam, we have two forms of it to contend with. The first, the globular form, which goes with the condensed water within the steam pipe, and the second, the vapor or volatile form, which is carried entirely by the steam.

The draft or passage of the steam, however, through an exhaust pipe is usually sufficient to carry the water of condensation that forms in the cylinder and in the pipes along with it and thus get rid of the water and incidentally carries the oil where the water goes.

It sometimes happens, however, that in a very large exhaust pipe the draft or mechanical force of the steam as it passes through the pipe is not sufficient to carry the water forward or upward, and this takes place where the exhaust pipe is very large or when the pipe is not doing its maximum duty. When the exhaust pipe is small in diameter, however, and the force of the exhaust sharp, it is gener-

ally able to carry the water of condensation out of the exhaust pipe in minute spray and by the same action the oil that is passed through the engine is carried along with the water and is thus thrown forward in the direction that the steam is going. The oil that remains vaporized, of course, will pass with the steam, no matter whether the velocity of the steam as it escapes through the exhaust pipe is high or low, as this oil is fixed within the steam and requires special treatment to separate it.

If, therefore, in our endeavor to separate oil from exhaust steam, we simply enlarge our exhaust pipe at some point until the steam as it passes through it has a velocity so slow that it is not capable of carrying its own condensed water with it, we have the first and one of the most important principles of a grease separator. When steam has not the power to carry its own water condensation forward it has not the power to carry a liquid oil forward and will leave it in any suitable pocket below the line of a suitable enlargement in the exhaust pipe.

An increase of one or two diameters in the pipe, however, will not reduce the velocity of the steam so as to have any appreciable effect on the amount of water that it is carrying forward. The enlargement must not only be great, but must be of some considerable length, and a change of direction in the current is also necessary. A small bulb in a pipe of two or three diameters greater than the pipe itself does not appreciably lessen the velocity of the steam through the bulb, nor will a change of direction take place without gratings or deflectors and the heavy particles such as water or oil are thrown like shot across the chasm and into the tube beyond where it is taken up and carried forward the same as through a simple fitting or valve. Deflectors in a small bulb or chamber, however, simply add obstruction to the free discharge of the steam without appreciably diminishing its velocity, so that the steam, to escape around the deflectors is forced to impinge on them, and instead of a deflector being of any service as a hindrance to the passage of the oil it acts as an obstruction to the passage of the steam in such a manner that were oil fed down upon the line of the deflectors the steam would pick the oil up and carry it forward, instead of depositing its own oil in whole or in part, as is now sometimes supposed.

The same is true, also, of small bulbs hung below a pipe with the hope that the oil will drip into them. This cannot take place in consequence of the bulbs having no practical magnitude, and the velocity of the steam through an ordinary exhaust pipe is so great that it carries the particles of water and oil straight through the apparatus, depositing little or none of the oil. This applies to condensed or

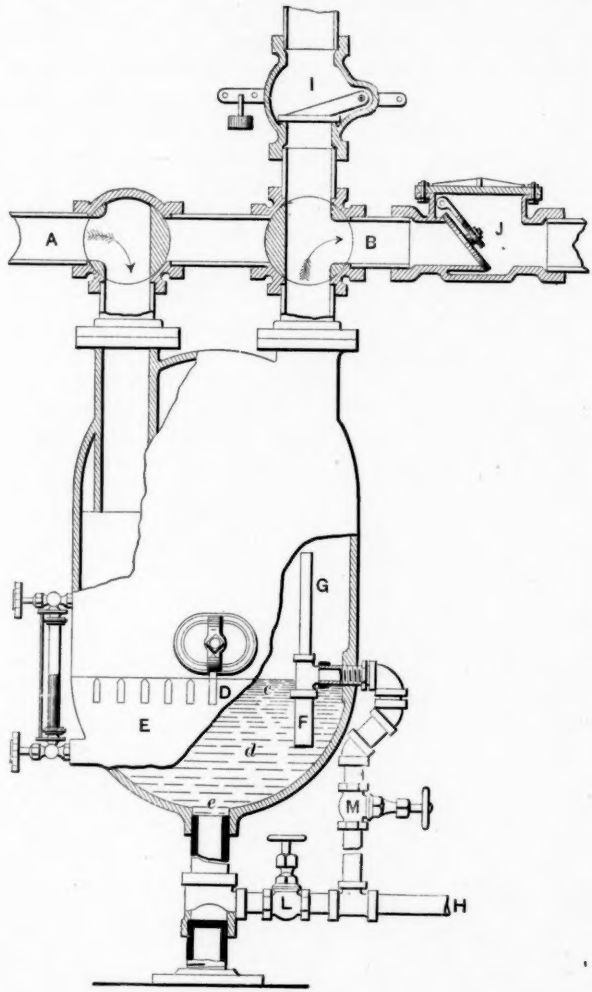
liquid oil and it is presumably not necessary to explain that the non-condensible vapor of oil held in the steam will pass through such an apparatus without change.

About ten years ago I was first compelled to look into this question very closely. Previous to that time no attempt had been made to separate grease from exhaust steam in the buildings of New York, for very little exhaust steam was used in heating. With the advance of the electric light engine, however, the amount of exhaust steam was so considerable in all of the important city buildings that it could not be neglected or thrown away and therefore had to be used in the heating apparatus. A study of the question at that time convinced me that there was no practical use in trying to separate oil from steam by what might be called mechanical means, such as straining or deflecting, or hanging so-called condensing or roughening surfaces within bulbs, unless, indeed, the bulbs had comparatively enormous diameters or bulk, so that the separation was by settlement, and it was found that when they had these great diameters it was not necessary to place any kind of obstruction device within the bulb except water to intercept the liquid oils. It was found that it was only necessary to change the direction of the steam by a simple elbow, so that the heavy particles of the water and oil would be carried, not horizontally but vertically downward, that they might be thrown against the surface of water held at the bottom of the bulb, where it was found that the oil and the water both remained.

It was also discovered that the lighter oils could also be caught and held within the apparatus by an arrangement of dams, though this was not anticipated at first.

The bulbs were arranged to maintain a constant depth of water at the bottom, which could be drawn off when desired for the purpose of carrying away the oil that accumulated. It was remarked that when steam and oil were projected on the surface of entirely clean water, the entire absence of oil was noticeable from the surface of the water in the receiving tank, but that when oil accumulated on the surface of the water a slight appearance of oil showed itself in the receiving tank. This led to further thought and development in the matter of the bulb. When watching the action of exhaust steam on the surface of the water it was noticed that at the moment when the puffs of the exhaust steam entered the bulb a clear space became visible on the surface of the water. The oil receded sidewise, exposing the surface of the water for the reception of the oil and condensed water that was coming with it, but that it instantly closed in between the puffs of the engine, exposing an oil surface again and thus alternating oil and water, until the oil accumulated to such an extent that the

clear spot on the surface gradually became smaller and thus impaired the efficiency of the extractor, oil apparently not being as good a surface to deposit oil on as water. This led to the construc-




tion of oil dams within the bulb, shown at E in the illustration, the upper edges of which dams are slightly above the water level of the apparatus, and their depth about three inches, with a high dam at D

to prevent the return of the oil over the surface of the grating formed by the low dams E.

It was found in practice that with this arrangement the surface of the water at E was depressed and that the general movement was towards the high dam D under the lower edge of which both oil and water passed, the oil accumulating at C and the water returning in an under current again at the lower level just under the edge of D to fill up the space between the grating formed by the dams E E. This water is thus kept continually clean and ready to receive each deposit of grease, and it has been found by actual practice that the lighter oils are condensed by the contact with the water, so that the process within the separator is akin to what one may call "washing the steam."

The illustration shows the entire arrangement of the grease separator. Steam enters at A through a three-way cock, is cleansed of its oil and passes out again through B, either through the check valve J to the heating apparatus, or through the back-pressure valve I to the roof. The accumulated water within the body of the apparatus is carried away through the overflow F, which is made non-syphonable by the open pipe G, allowing nothing but the excess of clean water to pass to the blow-off tank or sewer.

Occasionally the valve L is opened and the dirt, water, and oil blown out. The gradual overflow of clean water from F prevents the clogging of pipes or sewers which would be the case by the constant dripping of oil.

## DISCUSSION.

Mr. J. J. Blackmore:—There are one or two things I should like to ask Mr. Baldwin. He uses a good deal the terms "light oils" and "oil held in suspension." Are we to understand, in using a given grade of oil in a cylinder, that the oil separates into a lighter and heavier portion and that the lighter portion is held in suspension while the other is deposited? It is a point about which I am not quite clear, and yet I think it is what Mr. Baldwin assumes.

Mr. Baldwin:—What I have assumed is what I have seen. I notice that in some cases the oil used in the engine gives off what you may call a vapor at a high temperature, that condenses and passes away as oil (with the water) at a lower temperature. It may be that there are still some vapors so light that they are not condensed, but if there are, they are carried along with the steam and pass away, as we do not find them, except in the indication of grease that will appear around an apparently otherwise tight fitting.

Mr. Blackmore:—Do you know of any analysis ever having been

made of the oil that you caught to see if there were any properties in the original oil that were lost?

Mr. Baldwin:—No; no analysis was made. The only assumption is that it was a light vapor oil, as light or lighter than kerosene, of course, and those oils of similar character will vaporize where heavy oils will not. Most of the oils used are products of rock oil, and they have enough of the light oil remaining in them to appear again after the exhaust passes through the separator.

Mr. Blackmore:—I asked the question in order to bring out the fact as to whether you got all the constituents in the original oil—whether there were any left that you could not separate.

Mr. Baldwin:—I do not think chemical analysis would show that. Chemical analysis would simply show fat and carbon and other things of that kind; whereas the light oils would have the hydrocarbons and the heavy oils would not.

Mr. Cary:—I believe that most of the mineral oils used will distill portions of the oil which are more volatile than others; as they are heated the lighter part of the oil passes off. It is rather a difficult thing to describe precisely. But the oils used in engines and around pumps are very varied. We get all kinds, animal and vegetable and mineral oils, and they are very often mixed. Especially with the mixed oils we would have certain parts composing them that would be more volatile than others. The subject is too large to consider oil as oil. There are a good many different kinds of oils and a great many of the oils sold to people are not what they purport to be, as every steam user and oil buyer knows. Nearly all the oils that are used, or a great majority of those used about engines, are more or less mixed oils, and so we would get the lighter oils, as Mr. Baldwin expresses it, and the heavier oils combined, and of course those which would vaporize at a lower temperature would pass off as volatile matter and the others would have a less tendency to do that.

Mr. B. Harold Carpenter:—I should like to ask Mr. Baldwin whether, in his experience, there would be any difference in the action of the grease separator, whether you used a very low pressure—you speak here of using 100 pounds in running an engine—or a pressure from 10 to 25 pounds, as we do sometimes in heating work?

Mr. Baldwin:—Well, with a low pressure engine, that is an engine taking steam at low initial pressure, there would be less light oils—that is, oils that would evaporate at, we will say, 250 or 260 degrees F. would certainly evaporate in greater quantities at 300 degrees. I presume that would be the way to look at it—the higher the presssure the more the volatile portions of the oil will be made into what you might call a vapor; hardly a fixed gas. Oil does not

easily vaporize. It will largely remain as oil in the apparatus. The higher the temperature of the steam, however, the more oil will be driven into vapor.

Mr. B. H. Carpenter:—A separator would probably be more effective on a low pressure then, as there would be less drip.

Mr. Baldwin:—I think the final result would be the same, because we must consider our terminal pressures, not anything that transpired in the meantime. As the low pressure engine discharges its steam at about the same temperature as the high pressure engine, I think the question would hinge on the temperature of the exhaust more than on the initial temperature.

Mr. Miller:—I should like to ask the indulgence of the society, as I am a non-member. I should like to be allowed to ask a question or two of the reader of the paper. The question suggesting itself to my mind is as to how the grease in exhaust steam impairs the efficiency of a pipe for heating. Of course, we all know that the exhaust carries with it more or less of the oil, either entrained or vaporized, whichever way it may happen to be, and if that passes over a surface that is cooler, this oil is deposited on that surface, whether it is inside or outside. Now if there is any data in regard to the impairment of those surfaces as heating conductors by the presence of this oil, I should like to know of it, and, also, if there is no appreciable deterioration of the surface, why would it not be better, if you want to use exhaust steam for heating, to do all the extracting after it has passed through the system? Then, of course, you have the water which will carry a large amount of the oil, and the steam will be so depleted, or, as you might say, wire-drawn, as to be easily separated from the oil in this way.

Mr. Harvey:—You would find the return pipes would be filled up with the oil.

Mr. Cary:—I do not know of any information that has been obtained which will answer this question directly, but any one who has had any extended experience with steam boilers knows that oil is a non-conductor of heat, and a great many accidents have been caused, such as the crowns of furnaces coming down and bulging, by a very light film of oil, sometimes not exceeding one-sixteenth of an inch, running to an eighth of an inch. If this will obstruct the passage of heat in a boiler, you would naturally reason that it would be equally bad in a steam heating system. I believe that in the Engineering News, some one or two years ago, some experiments were given showing how much heat was obstructed by interposing a light film of oil between the boiler plate and the water, and it can be found on record in that paper, though I do not remember in what number.

Mr. Baldwin:—I should like to state, Mr. President, that 25 or 26 years ago, in Detroit, when we used tallow in our cylinders, I have taken out a two-inch pipe that had been entirely closed up with the heavy deposit of grease.

Prof. Carpenter:—In answer to the question as to experiments of that nature, I might say that last year we made some experiments in our university in connection with the transmission of heat through iron plates, clean and covered with scale and grease. The results indicated that about one-twentieth of an inch of oil was equal to about two inches of scale in preventing the transmission of heat.

Mr. Baldwin:—I would state for the information of the gentlemen present that when oil is carried into boilers the usual form in which we find it is that which is generally called slugs. It does not lie in a film over the body of the boiler, and for some reason it seems to mass up into shallow lumps that look like big snails, and if these lumps happen to aggregate and get on the shell or a hot part of the boiler, immediately over the fire, there will be a sag or blister very quickly with iron boilers. With steel boilers this is not so apparent, but the injury to the steel is as great and can be observed on close inspection; and the danger is greater, and when boilers are not properly cleaned, as in small tube boilers, the injury from those slugs will destroy the boilers.

Mr. Barron:—This is a very valuable paper of Mr. Baldwin's. He has had a great deal of experience in exhaust heating, and the paper is particularly valuable, because it is the result of practical experience. I have used a good many of the eliminators in the market. I should like to call Mr. Baldwin's attention to his back pressure valve and check valve. I think it would be very noisy. The check valve would give the pulsations of the engine, and the back pressure valve—we cannot use that. I suppose he merely put them in there because they were easy to draw.

Mr. Baldwin:—They are only diagrammatic.

Mr. Barron:—In regard to Mr. Baldwin's method of leaving water in the eliminator, I have never done that. I connect the drip pipe to the eliminator and put on a siphon trap. In regard to his method of drawing off the oil, I think it is very good, but it is objectionable, owing to the fact that the engineer or fireman has to go there to attend to it. I think the most important problem in using exhaust steam is to get rid of the grease. I have been bothered in two directions—one, the offensive smell of decomposing fat from the radiators; the other, the injury to the boilers by the grease settling over the fire and having the heads start leaking at the line of the rivets over the fire arch in the ordinary horizontal tubular boiler. I

have used various grease extractors, but all made on the principle of steam separators, which I believe is the wrong principle for getting rid of grease, no matter how successful it may be in taking entrained water from steam. The best extractors I have used were large cylinders having an internal pipe where the fall of pressure due to the enlargement of the exhaust pipe caused a precipitation of the grease to the bottom of the tank. The form is, of course, extremely crude, but it is much better than the small cast iron affairs that do not give room for the steam to pass through and have no room for a fall of pressure. I have thought that a machine like a centrifugal extractor or wringer running at a very high speed would make a good grease extractor. I have again thought that a paddle arrangement in the exhaust pipe would possibly be the correct thing, the steam striking the paddles depositing the grease and the grease dropping to the bottom of a proper receptacle. It may be found that it would be advisable to steam-jacket a water or grease extractor in order to get a temperature in the extractor of high pressure steam, and this might be found to precipitate the deposition of the grease on the side of the extractor; or a cold water jacket, by producing a sudden fall in temperature, might produce the same result. I have in one case, with good results, put an extractor on the exhaust from the engine where it enters the distributing tank and another extractor on the exhaust where it leaves the tank to connect with the heating system. I want to say in all my exhaust heating I carry the exhaust to the tank on the plan proposed by Mr. Bates years ago, but I presume practiced by others before his time. I am afraid that our effort to improve the methods of removing grease will not have much bearing on the development of devices for that purpose. These things are developed by the specialists, and they get more practical knowledge in one month from the failures of their devices to work than we could get by talking about the subject for ten years.

## XXVII.

# DETERMINING THE VOLUME OF AIR PASSING THROUGH A REGISTER PER MINUTE.

BY J. H. KINEALY, ST. LOUIS, MO.

(Member of the Society.)

In determining the volume of air flowing through a register per minute it is customary to determine the velocity in feet per minute at the surface of the register by means of an anemometer and then multiply this velocity by either the area of the face of the register or some fractional part of this area. It is seen that the determination of the volume of air flowing through the register involves two separate and distinct problems, as follows:

1. The determination of the velocity of the air by the anemometer.
2. The determination of the fractional part of the area of the face of the register by which the velocity should be multiplied.

One method of determining the velocity of the air is to move an anemometer from side to side in zigzag lines over the face of the register and get the reading for an interval of one minute. The anemometer is usually held about one-half an inch from the face of the register.

A second method is to hold the anemometer for one minute at each of four points on the face of the register and get a reading of the anemometer for each point. The points are usually about the centers of the areas obtained by assuming the face of the register to be divided into four equal parts. The average of the four readings is taken as the velocity of the air.

A third method is to divide the face of the register into a number of small rectangles, each about three or four inches by four or five inches, and hold the anemometer at the center of each of these small rectangles for ten seconds and get a reading. The average of these readings is taken as the velocity of the air for ten seconds and this multiplied by six gives the velocity for one minute.

The first method is the one usually adopted in tests, because it takes less time than either of the others, and if the velocity of the air is not great this method will probably give quite correct results. But if the velocity of the air is great, especially when there are

dead or negative areas on the register, great care is necessary in order to get correct results by this method. By dead areas are meant those small areas often found on the faces of the registers at which the anemometer will show no air coming out of the register nor no air entering; the velocity is zero. By negative areas are meant small areas often found on the faces of registers at which the anemometer shows that air is *entering* the register; the velocity is negative. Dead areas and negative areas are very common on registers of hot blast systems of heating; they are at the bottom of registers in walls, and in floor registers are at the end nearest the hollow of the bend of the air pipe. In Figs. 40 and 41 *a* indicates where dead or negative areas are usually found in wall and floor registers; the lines indicate the flow of air through the registers.

These dead areas and negative areas are caused by high velocities of the air in the pipes leading to the registers, and by shallow reg-

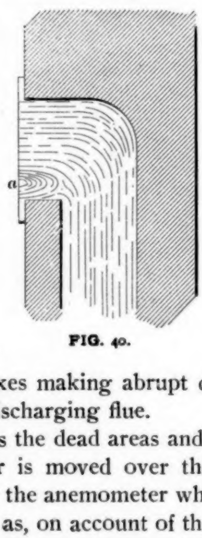



FIG. 40.

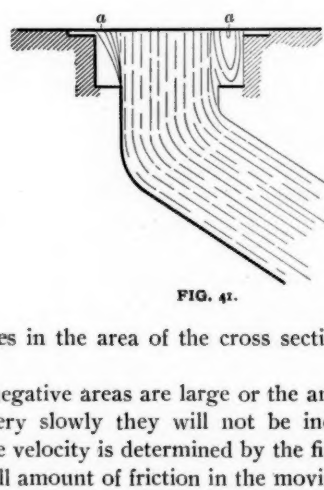



FIG. 41.

ister boxes making abrupt changes in the area of the cross section of the discharging flue.

Unless the dead areas and the negative areas are large or the anemometer is moved over them very slowly they will not be indicated by the anemometer when the velocity is determined by the first method, as, on account of the small amount of friction in the moving parts of the anemometer, it will continue to run while passing over these areas and will register positive velocity when it should register either no velocity or negative velocity. The anemometer the writer uses will run until it registers 20 to 25 feet after being suddenly removed from the action of a current of air having a velocity of about 800 feet per minute.

By the second method of determining the velocity the dead areas, the negative areas, and the areas of greatest velocity are usually avoided, but as this method will usually require at least five minutes

to determine the velocity of the air at one register, and as much care and judgment must be used and often some preliminary experiments made in order to determine where to hold the anemometer to get average readings, it is not much used.

The third method gives excellent results, and if the face of the register is divided up into small areas, each not much larger than the face of the anemometer, it will give a more exact result than either of the others. The objections that can be urged against it are that it takes some time to mark off with chalk the small areas and that longer time is required to determine the average velocity after the areas are marked off than is required by the first method.

After the average velocity has been determined the question that then arises is: What area should this velocity be multiplied by in order to obtain the volume of air flowing through the register per minute? It is evident that if this velocity were the velocity of the air as it passed through the openings in the face of the register, the proper area to use would be the actual area of the openings. The different streams of air from the openings mingle and mix to a great degree directly at the face of the register when the partitions between the openings are small, and as this mingling is accompanied by a reduction in the average velocity it is evident that if the mingling and mixing were perfect the proper area to use would be the area of the face of the register.

Let V be the volume in cubic feet of air passing through the register per minute; v the average velocity per minute as determined by the anemometer held about one-half an inch from the face of the register; A the area of the face of the register in square feet; and x a factor to be determined. Then

$$V = xvA$$

If by a series of experiments we can determine V, v, and A for a given register we can then find $x = \frac{V}{va}$. Having once found x we can use it afterwards to find V when v and A are known. It is probable that x will vary slightly with v and with the ratio of the area of the opening in the register to the area of the face.

In order to determine x the writer made a number of experiments upon a floor register of a room on the first floor of one of the buildings of Washington University, St. Louis, Mo. The air was forced into the room by natural draft from a large indirect steam heating chamber in the basement. The experiments were made on different days, so as to get different values of v. The only occupants of the room during the experiments were the persons making the experi-

ments and care was taken to keep the conditions as nearly as possible the same during each set of experiments.

The face of the register was about 13¾ by 21¼ inches and its area was 292 square inches. The diameter of the pipe leading to the register was 14½ inches and the area of the pipe was 165 square inches. The area of the openings in the face of the register was found to be 0.60 of the total area of the face of the register. In order to determine this the register was laid face down on a piece of heavy detail drawing paper and a careful tracing made of the outline of the face of the register and of each of the openings in it. The paper was then cut along the lines indicating the outline of the face; this gave a piece of paper of the exact dimensions of the face of the register. This was weighed. Then the pieces of paper corresponding to openings in the register were cut out and weighed. The weight of all the pieces of paper corresponding to openings was found to be 0.60 of the weight of the piece of paper the size of the face of the register.

The volume V of air passing through the register was determined either by measuring the velocity of the air in the pipe leading to the register and multiplying this by the area of the pipe, or by measuring the velocity of the air passing through a box set on top of the register and multiplying this by the area of the box. The box was exactly the same size inside as the face of the register and two feet high.

Test No. 1.—The register was taken off and ten readings were taken in the pipe, then the register was replaced and ten readings were taken at the register face. The anemometer was moved about in the pipe continually in order to obtain an average velocity. The velocity at face was found by moving the anemometer about over the register while held at a distance of from one-half to one inch from the face.

Test No. 2.—The readings were taken in the pipe; then ten readings were taken at the face of the register with the anemometer about one-half inch from it; then the box was set on the register and ten readings were taken with the anemometer held just inside the top of the box. While getting the readings in the pipe at the register and in the box the anemometer was kept moving about in order to get an average.

Test No. 3.—This was made the same as No. 2, but made on a different day.

Test No. 4.—The face of the register was marked off into eight equal parts and the anemometer was moved about over each of these parts, just touching the face of the register for one minute, so as to

get the average velocity at each. The velocity of the air through the pipe was found the same as in the previous tests.

Test No. 5.—The mouth of the box was divided into eight equal parts by fine twine stretched across it and then the box was put on the register and the anemometer was held in each of the small areas ten seconds. These readings were added together, divided by eight and then multiplied by six, and the result thus obtained was taken as the average velocity. This was done three times; then the box was taken off and the average velocity at the face of the register was twice found by the same method used for the box. Then the register was taken off and the average velocity in the pipe was found three times.

Test No. 6.—This was almost the same as No. 5, except that the face of the register and the mouth of the box were each divided into 12 equal parts. The average velocity of the air was obtained by holding the anemometer in each of the small spaces for ten seconds, then dividing the sum of the readings thus obtained by 12 and multiplying by six. The average velocity at the face of the register and at the mouth of the box was obtained five times each.

Test No. 7.—In this test the box and the face of the register were each divided into twelve parts, as in test No. 6, and everything was about the same, except that as soon as an average velocity was determined at the mouth of the box it was taken off and the average velocity determined at the face of the register.

RESULTS.

After all corrections had been made the values of x were found to be as follows for the different tests.

| No. of Test. | Value of x. | | Average velocity of air at face of register. |
|---|---|---|---|
| | V determined from pipe. | V determined from box. | |
| 1 | 0.85 | .... | 109 |
| 2 | 0.67 | 0.80 | 194 |
| 3 | 0.80 | 0.92 | 168 |
| 4 | 0.65 | .... | 101 |
| 5 | 0.63 | 0.78 | 132 |
| 6 | .... | 0.81 | 195 |
| 7 | .... | 0.76 | 147 |

The writer does not think that much weight should be given to the values of x obtained by determining V from the readings of the anemometer when held in the pipe, as the velocity of the air was much greater near the center of the pipe than at the circumference, and it was almost impossible to move the anemometer about in the pipe so as to get an average value of the velocity of the air.

The average value of x when V was determined by the pipe is 0.72, and the average value when V was determined by the box is 0.81.

A short time after making these experiments the writer had an opportunity to make some others on a floor register whose face was $23\frac{3}{4}$ by $23\frac{3}{4}$ inches, through which air was forced by a fan. In these experiments the volume of air passing through the register was determined by placing on it an air tight box $23\frac{3}{4}$ by $23\frac{3}{4}$ inches inside and two feet high. The face of the register and the mouth of the box were each divided into 16 equal parts, and the average velocities of the air at the face of the register and at the mouth of the box were obtained by holding the anemometer in each small space for ten seconds and getting a reading. The value of x obtained from these experiments was 0.88.

I am inclined to think that x should be taken in all cases as about one-half the sum of one and the ratio obtained by dividing the actual area of the opening in the register by the area of the face of the register. As the actual openings in the ordinary registers are about 0.67 of the area of the face, this rule would give $x = \frac{1}{2}(1 + 0.67) = 0.83$; or, say 0.85.

This rule will be found to be accurate enough for all practical purposes as x will differ with the register, the way it is set, and the velocity of the air passing through it.

## DISCUSSION.

Mr. Wadsworth:—I would suggest that the method adopted by Prof. Kinealy for determining the free area of the register might possibly be improved by the use of the planimeter.

Mr. Wolfe:—If we have in a pipe an area of 165 square inches and an area in the register of 292 square inches and we get a velocity at the pipe of 85, if I understand this table correctly, how are we going to get more air through a larger opening in the register, which is 109 as against 85? How are we going to get more air in a room than passes through the pipe, except we fix it up by friction, when it could not be figured as fresh air? Take test No. 1. The velocity in the pipe was determined from the pipe at 85 and the average velocity at the face of the register 109.

Mr. Kent:—That is not velocity. That is the value of x, the coefficient. This is simply an arithmetical coefficient in the formula. That equals, as I understand it, the value of x when v is determined from the pipe. That first column does not mean the value of v, but the value of x.

Mr. Miller:—To my mind it is a very easy matter to determine the amount of air that passes a given point in a given time when you have all the instruments necessary to measure it with. While the paper is good in every respect, yet to a man who is wondering why, in work, an old furnace does not work, it is a different thing, because you have nothing to measure it with. You might take a thermometer and tell the temperature of the air outside and inside, but how is he going to tell by that how much air he is getting in the room? I tried a little experiment on a radiator and found that the air going into the box at 60 was heated to 140 degrees at the point where it went out, and the inlet and outlet were nine inches by six in that test. Now, if there is any rule by which the amount of air passing through at that point could be determined, I should like to know it.

Mr. Wolfe:—There is such a rule, sir. I don't recall the book now; but I think it is also in Prof. Carpenter's book. There is a rule which would give you the volume when you know the area of the opening through which the fresh air enters, the temperature of the air at outlet, the height that it travels, and the temperature at the outlet at that height.

Mr. Kent:—I should like to ask, as a matter of information, how the amount of air passing into a room for ventilation is determined under the Massachusetts laws, so as to find whether you have 2,000 feet of air per hour per capita or not. I understand from Prof. Kinealy's paper that it is customary now to determine it by an anemometer. But there is a coefficient of correction to be applied which may be in error. I should like to know how it is done in Boston.

Mr. Wolfe:—It is a kind of rule of thumb business there when you get right down to it. You cannot by an anemometer that would show the same rating as mine. There are no two that run alike. The inspectors determine it in this way: They get their anemometer as near right as possible, and they assume they are right. Our openings there, of course, are always above. They start at the bottom of the register, where, under the ordinary constructions, there is no movement, and move the anemometer upward as slowly as possible; until it begins to move—it ordinarily cuts off the lower part of the register about 12 inches or something like that. Then they draw a line across the register at the point where the anemometer began to move and take a reading at each corner and possibly in the center of the area bounded by the top and sides of the register down to the

chalk line, and they will divide the total by the number of readings that they have taken and multiply that by the velocity, and then if it is a cast iron register face, deduct 33 1-3 per cent, or, if it is a wire register face, deduct 12½ per cent or one-eighth.

Mr. Kent:—Prof. Kinealy's figure was about fifteen per cent. His coefficient was .85.

Mr. Wolfe:—All register manufacturers calculate that the obstruction to the free area of an ordinary register amounts to about 33 1-3 per cent. What we use more largely there than anything else is wire screens, and there we gain, of course, because they only cut off one-eighth. I have tried taking off the register and face and getting more free delivery space and putting it back and didn't find much difference. But the state inspectors take off this third just the same. Now here is the question: Is it right to take it off from the inlets and not take it off from the outlets, or vice versa? There is obstruction in one case or the other, and where it ought to come I don't know. They take it off on both ends.

Mr. Jellett:—The first method described by Prof. Kinealy is the one generally adopted—the average of the readings of the register face—but I have never found by actual measurement of register faces that I got anything like the percentage mentioned. The pattern known as the plain lattice pattern, which has more openings than any regular patterns I have used, at best has given me about 65 per cent per opening. I have taken readings on the basis of 65 per cent effective delivery. I have frequently found at the bottom of the register, where a round top flue was used, that practically no velocity existed on the lower level. If there is no velocity we deduct that much of the actual surface of the register as amounting to nothing and we take the area of the section of the register on which there is an actual delivery. There should also be a method of determining the volume of air going out from the flues located in the room in which the air is delivered. I frequently find that tests are made entirely of the incoming volume of air without any reference to the ventilating flues. I think that is a mistake. I think we ought to know where the air is going. I have in mind a building at the present time on which I made a series of experiments a short time ago. The first floor is ventilated by flues leading to the basement, connected by a series of ducts to the exhaust fan driven by a motor; flues to the second floor and the intermediate story go to the attic, in which there are two aspirating chambers. The specifications for that building required that a certain volume of air should be delivered, to be measured by the anemometer at the discharge of the registers, and that the velocity of air coming in should not exceed 400 feet per min-

ute from the registers, which were close to the floor, and that the velocity should not exceed 600 feet on the upper line of registers. It was also called for in the specification that each outgoing ventilating flue, or that the sum of the ventilating flues in any one room, should take out four-tenths of the air delivered into the room. We made some experiments to find out the amount of air lost through the walls and through the doors, and there is always a certain amount of moving in and out through the doorways. We were therefore not asked to take off a very large quantity through the ventilating flues. If the entire volume was required to be taken out the vent flues the exhaust fans and aspirating coils would have to be of such proportions that during the incoming of a large number of people the room would be chilled; so we fixed that the aspirating coil should take out four-tenths of the air delivered by the blower system. That is found to work satisfactorily. The main assembly room in the building has a novel method of introduction of air. It is a room some 60 feet wide by 100 feet long. The ceiling, I should judge, is about 42 to 43 feet high. The requirement to be met was that 2,000 cubic feet of air per minute should be supplied. The architect did not want the walls cut for flues. We therefore had the first story wall with hollow spaces and we carried that up into the second floor of the building, forming a wainscotting around the walls 7 feet 6 inches high. That wainscotting is really a continuous flue on the two walls of the building. Into the top of that there is set a wire screen. You go into the room and see no heat supply registers whatsoever, and the air is delivered at a point 7.5 feet above the floor. There is a series of outgoing registers set into the base-board which are always open. There is, in addition to that, in the ceiling six very large plaster ornaments, which are perforated. They are covered in the attic by galvanized iron ducts, which also lead to the aspirating chamber, so that the amount of air taken from the ceiling and from the floor can be regulated. The operating dampers are controlled in the hall by chains at the rear of the stage. We can have the lower vents in full operation. We can also have the ceiling registers doing partial work, so as to get a very equal distribution of air throughout the room. On the incoming supply we have means of controlling the temperature so as to regulate it. That is found to work in practice very satisfactorily. I think that in rooms in which there is a small number of people and where they are likely to be in session some time, in determining the volume of air coming in we should go a step farther and determine the amount taken up by ventilating flues, so that we may know what the ventilating flues are expected to do, and that they may be figured accordingly.

Mr. Barron:—I should like to ask Mr. Wolfe a question in regard to the practice of the Massachusetts District Police. Do their usual anemometer tests agree with the calculations of the heating and ventilating engineer—the man who puts in the apparatus? Do the tests of the police generally agree with his calculations and his experience? That is, are the tests fairly reliable from the method they pursue?

Mr. Wolfe:—I think they are as reliable as could be expected. We do not get any money until we comply with the requirements. We figure in about what it will be and add 20 per cent area and 20 per cent in service and 20 per cent in power. In that way we are pretty apt to hit on the right side. The thing is right here: We go into a building and the temperature is 20 degrees F.; the thing is all right; no fault to be found. We go into the building to-morrow and the outside temperature is 40 degrees F. and everything is wrong. Now we protect ourselves in this way. It is part of our contract that no tests shall be made regarding the introduction of fresh and the exhaustion of the vitiated air, excepting when there is a difference of temperature of at least 40 degrees between the room inside and the outside atmosphere; and then we get down to a basis where we come pretty near together. As I say, when we figure out by rule as to what was really necessary as to capacity of flue, sizes of registers, and matters of that kind, I do not think they exact anything too much from us. They make us attend to our business, and as long as we have to attend to our business we will do it. It is as easy to do it right as it is to do it wrong.

Mr. Kent:—I am very glad to hear this confession from the gentleman from Boston. It explains something I have found in schoolhouse ventilation, and I never before could understand it. Now, he says that contractors will only make tests of the gravity system when there is a difference in temperature of 40 degrees between the inside and the outside air.

Mr. Wolfe:—No. That has nothing to do with it. That is in our contract. That is what we agree to do—that when that condition exists we will guarantee such and such results, but it has not anything to do with the state officers, you know.

Mr. Kent:—It is a very satisfactory method, this one of putting 20 per cent more of everything. That is good engineering. But I am especially interested in this peculiar feature of the gravity system—that we cannot get the proper amount of fresh air into the rooms unless there is a sufficient difference of temperature to make the motive power to carry the current. Now, in schoolhouses heated by the gravity system, I have noticed that on a warm March or April day, when everybody feels like being out of doors, the ventilation is

abominable, while in winter time the ventilation may be all right. This statement made by Mr. Wolfe seems to explain it, namely, that when the temperature outdoors is about 65 degrees and the temperature indoors is, say, 75 degrees, there is practically no ventilation in the school; there is not enough difference of temperature between the outside and the inside. That is no fault of the contractor's. It may be no fault of any particular person, but it shows the extent of our ignorance regarding ventilation and that there is something wrong in our system of ventilating schools. On the very days when the children ought to have the most air we are poisoning them with impure air.

Mr. Wolfe:—I do not agree with you there. It is not any question of ignorance. It is a plain question of old-fashioned dollars and cents. That is all there is to it. We never have signed a contract so long as I have had to do with our company in which we agreed by the gravity system to do anything except to supply fresh, warmed air. No committee has ever heard me get up before it and say this thing can be done without a mechanical system where we will give you a guarantee for 365 days in the year. It is a question of the three, four, five, or six hundred dollars that the committee will not pay us to put in what ought to go in. That is where the point comes in. No system of ventilation, in my mind, can be controlled and be considered a perfect system excepting it has mechanical methods or the equivalent of mechanical methods to take care of it when there is a very little difference of temperature between the outside and the inside. I do not believe that any gravity system in the world, without some sort of power back of it, will do for every day in the year.

Mr. Kent:—I hope the gentleman will not understand that I made any criticism whatever of him, or his form of contract.

Mr. Wolfe:—I do not take it so. The point I wanted to bring out is exactly what has been said, that the gravity system of ventilation is a failure for schoolhouses and that we must come to mechanical means, and that thing should be explained thoroughly to school committees and boards of education and all others who have to take care of children. In nine-tenths of the schools built in the United States more money is wasted than would pay for a first class heating apparatus with a supplementary apparatus for use whenever needed. I do not know that all of these gentlemen go out for business. I do. I tell my committees that the only perfect system of ventilation to-day is the system of ventilation that will give so much air every day in the year. Even in January there are days when you cannot get good results by gravity. "Well," they say, "We have only so much money." I say to them, "There is a gravity system and we can lay it out, and at

such a time in the near future as you see fit to put in a mechanical system you can do it." That is as far as they can go. I admit that we have put up such apparatus. I know the ventilation is bad and the teacher does not need to tell me it is so. The windows are bound to be kept closed and they do not get anything like 30 cubic feet of air a minute or even three cubic feet of air per minute through the building. There is no air going to be lifted from the basement, possibly 35 or 40 feet down, away up to the schoolroom and then carried out of the building. Where it comes through a doorway, when there is a coat room or anything of the kind, it is going to short circuit just as quickly as water or electricity or anything of the kind, and the result is a horribly bad school, but it is not your fault and it is not mine. I have told them what they need and they won't buy it; they say they have not the money. Of course we would a good deal rather take what they have than not get any.

Mr. Baldwin:—Mr. Kent asked the method of measuring the air in the Boston schools. That suggests to me that any person measuring air at registers in rooms should go to the point of inlet and measure the air there also and see if the qauntity found at the register agrees with the amount coming in at the inlet to the fan. If there is no great discrepancy found this way. it is one point in favor of the accuracy of his methods and measurements. A method used by myself to determine exactly what passed through a register, so as to eliminate the errors due to fret work, is to place a pasteboard funnel over the register. The opening which I provide at the small end of the funnel I endeavor to have as near as possible the same size as the flue. I have obtained with it results that would check up very closely with the amount of air passing through the fan.

Mr. Blackmore:—I want to say a word or two about the gravity system that has been so harshly condemned. Mr. Wolfe made a statement that it required a difference of temperature of 40 degrees between the inside and outside air to get certain results. It is a well known fact that you can get better ventilation at some times than you can at others. It is also well known that a heated flue is used in milder weather. It has been demonstrated that if a proper heating furnace is put in this stack you can get good ventilation. There is no question but that mechanical ventilation is better and cheaper when you can use this system, but that a flue can be arranged so as to produce an outflow of 30 cubic feet of air per capita if a proper furnace is placed in the stack and properly attended to, has been demonstrated repeatedly. If it is not properly attended to, we know the results obtained are poor, but that does not alter the fact that the gravity system, if it is properly put in and properly attended to, will produce good results.

Mr. Kenrick:—I would say that I have in my possession a copy of the report of the Massachusetts District Police where it states that I am giving 65 cubic feet in a plain aspirating shaft.

Mr. Wolfe:—When we come to a plain aspirating shaft and the gravity system, we have a school down in Greenfield where there is a gravity job. At seven below we give 95 feet per capita. There is no trouble about that. But I do not believe that a good business man is doing good business when he guarantees on the gravity system to give 30 cubic feet of fresh air per minute without a qualification as to what the conditions shall be, inside and out. There are days and days. You get a good, clear, breezy day and the temperature may be up to 65 or 67, and there are schools so situated that, the atmosphere being clear, and the breeze helping the draft along in the chimney, we might get 30 feet, but my experience is that the state inspector does not get along that day. He may come some other day, and we are then condemned for not doing what we agreed to do. As a result, I print plainly in my contract and proposal that I do not guarantee results except the difference of 40 degrees exists.

Mr. Barron:—My impression is that there has been no improvement in registers in the last 25 years. The present register is heavy. It obstructs the air passing it. It seems to me that it is possible to evolve better devices. I know most of the ventilating engineers who make a specialty of that work put in different registers from the ordinary ones in the market. I had occasion a little while ago to design a ventilating plant for an assembly hall having several galleries. I deducted 20 per cent from the tables given by the manufacturers for area of opening and made the vent registers 25 per cent larger than the inlet registers. I did it on the basis of Mr. Wolfe's 20 per cent.

Mr. Wolfe:—I use a larger register than the flue. As an example, we will suppose that the flue is 24 by 24. I have a screen made that is 24 by 36, because when the inspectors come to measure, if their anemometer has not been recently oiled or something of the kind, the thing might not begin to move, and we want to show that air is coming through, and this practice of making the register larger gives them considerable lee way. I do not gain anything. I am not deceiving anybody, but I am giving them a foot to measure in below.

The President:—In measuring the velocity of air entering through registers I have preferred, in every case where it is possible, to erect in front of the register a pasteboard or pine wood box which could be gradually tapered down to the area of the flue at the distance of one foot or six inches from the wall, the measurements to be made at inner edge of this box. I think it gives fair results, as it gives room

to work the anemometer. The method which Prof. Kinealy describes, of measuring close to the register, I have never practiced for the reason that it seemed to me very uncertain in its results, because of the various eddies likely to be found. He has given us some coefficients for correcting those results which I think are very valuable. In all the designing I have done in this kind of work I have invariably called for registers 40 to 50 per cent larger in area than the flues for two reasons: first, to reduce the friction of the air entering the register, and, second, to let it enter the room with a less velocity than that in the flue, which is generally desirable. I have seen very recently some special screens of wrought iron which obstruct the area very much less than the ordinary cast iron registers in use. I think those special screens in which the grills are of wrought iron can be obtained for all sizes of flues. They are much neater looking and much more efficient than the usual old fashioned cast iron register.

Mr. Jellett:—I never use a heat register less than twice the area of the flue. We will assume that the flue has 72 square inches of area—six by twelve—a small flue. I should take twice that area on the face of the register, because I actually do not get more than the space I need plus the friction. You would have 144 square inches, but you really get 60 to 65 per cent of that effective. If the flue is very shallow I make the register two and a half times. The outgoing ventilating registers have no valves in. They are never less than one and a half times. Usually the architect prefers to select the design, and the clearance in the designs varies. The most I have ever gotten in a standard cast iron register is 65 and a fraction. With wire screens made of No. 12 wire you can get about 88 per cent clearance, but they are not often used in the better class of work.

Mr. Baldwin:—In schools for which I recently designed a heating apparatus for the city of New Haven I have in two of them entirely done away with bottom registers. I had the bottom vent hole plastered and finished just the same as the walls of the room (hard finish), and an iron frame was put around it, so that the children could not knock the corners off. This gives chance to test it and to clean the bottom of the flue, and it is my judgment the proper thing to do for bottom vent openings in schools. In some buildings where the vent flue is continuous this cannot be done. You must have a register of some kind, and probably the best thing is to fall back on the ordinary register, making it as large as possible. Where the hot air comes in a room seven or eight feet above the floor I follow the same method as the gentleman from Boston, simply using a frame and as light a wire as will prevent the children from throwing paper balls into the flue.

## XXVIII.

# ARRANGEMENT OF MAINS IN HOT WATER HEATING APPARATUS.

BY W. M. MACKAY, NEW YORK, N. Y.

(Member of the Society.)

Considerable interest is manifested in the proper placing of the hot water heating system judging from the many and varied questions on this subject which have been handed in to the society by the members from year to year for discussion, and as the success of a hot water heating apparatus is largely dependent on and effected by the arrangement, size, and grade of the flow and return mains and their connections, I will endeavor to present such information as to results as I have gathered on this subject, being my own experience in planning and placing this system in different classes of buildings, my observations of the results obtained by others, and such descriptions of earlier systems as I have been able to obtain. While much has been said and done to popularize and increase the use of this system during the past 20 years in this country, Canada, and Europe, the origin of the system seems shrouded in doubt and dates farther back than the earliest writers on the subject have been able to determine, many of the so called improved applications of the system which have been presented during the past few years as new discoveries in the art having been found to be but a revival of older ideas and an accurate description of apparatus which actually existed, in some cases, years before the modern inventors and patentees were born, and being what some of our present writers would term obsolete or antiquated.

We have no means of knowing how well or how poorly these earlier systems operated or what advantages or defects they possessed, except by considering the results obtained in similar applications in modern systems, although all hot water apparatus described by earlier writers seem to have accomplished the desired results and are said to have been satisfactory. From a careful examination of the various published descriptions and cuts there would seem to be no real reason why they should not have given good

results, apart from the fact that in those days they did not have the variety of sizes of pipe nor the assortment of regular and special fittings that can now be obtained, and yet with these difficulties to contend with in many of the earlier apparatus engineers actually attempted and seem to have accomplished under adverse circumstances more than some modern engineers would be willing to attempt to-day.

Mr. T. Bramah in 1836 described an apparatus which he placed in 1829 which contained the features of the overhead system as advocated to-day and which is also a good description of modern greenhouse heating practice; he also published a description of the heating of a hospital building in which he gives a clear description of the present method of installing an indirect hot water apparatus, in addition to which he also heated the water for domestic uses from the same apparatus and seems to have originated the practice, which is still followed by some engineers, of casing in the heater, circulating air over it, and passing it up through registers for heating rooms above. He also described what would to-day be considered a modern direct radiating hot water apparatus; in this system he feeds the radiators at the top, the return being at the opposite end at the bottom, connecting the expansion tank to the upper end of the flow and return mains, doing away with the use of air valves.

Mr. Charles Hood in 1837 published a general description of hot water heating methods at and previous to that time, and while his treatise does not illustrate or describe actual installations the methods he describes are largely followed in practice to-day.

Mr. C. J. Richardson, a British architect, published a treatise on warming and ventilation in 1837 and while this work is largely a description of the Perkins high pressure hot water system as applied in different ways to different classes of buildings at and before that time, the general arrangement of the mains, apart from the sizes (which are smaller than would be used to-day), clearly describes the different arrangements of mains that are now employed in this system, the continuous circulation, the rising main, the overhead falling main for supplying indirect stacks, and the overhead system, the rising main being carried to a point below the radiation on the upper floor, the radiation on the different floors below being supplied from downward branches with a pass by. He also describes and illustrates a half-turn cylinder valve similar to the present constructions, except that it was also arranged as a three, four, five, and six way valve for controlling or diverting a number of circulations.

The arrangement of mains which is most largely used in an ordinary installation of hot water heating apparatus at the present

time is a number of flow mains rising from the source of supply to the farthest point to be reached, with a corresponding number of returns of the same size on the same grade falling back to the heater. Some engineers contend that this is wrong and that the radiation would be better and more uniformly supplied with a single flow and return main in the same way, but this statement should always be qualified and the existing conditions considered before it is made, for even a novice will admit that if the heater is placed at a central point to supply radiation in four different directions and this system of mains be employed it would be better supplied by four separate flow and return mains from the heater than by a single main, and while it is true that when the radiation is located in one direction from the heater it is often possible and practical to supply it with a single main there is a limit in size or diameter beyond which it is not safe or wise to go and after reaching this limit it is an advantage to use two or more mains rather than to increase the size of a single main. While larger mains have been used and recommended, I have always found it best to place the limit at from eight to ten inches diameter, depending on the conditions, my objection to a larger main being the large body of water it contains, the difference in temperature between the top and bottom of the main causing unequal expansion, and the possibility of an internal circulation interfering with the general or desired circulation.

I have in mind a large building which was heated by hot water some years ago; in one section of it, about 60 by 40 feet, the main was carried from the heaters to the outside wall and continuously around it back to within 20 feet of the heaters, making this single main about 180 feet long. The circulation in this main has never been uniform and with a low temperature of water the far end of it for about 80 or 90 feet is almost cold, whereas if two mains of a smaller size had been used each of them would have been 90 feet long and they would have given an apparently uniform circulation. While it is claimed that it is impossible to hold cold water above hot water in a hot water system it is possible in this case and in any case where, on account of a large main and a free circulation through the radiators and risers near the heater, the water is allowed to enter the return main near the heater at, say, five to ten degrees lower than the temperature of the flow main; the natural tendency of this heated water in the return main is to travel towards the upper end of the main instead of returning to the heater and under these conditions, as soon as a sufficient number of radiators and connections are circulated to relieve the heater at the temperature at which it may be operated, the two columns of water at about the same temperature traveling

or attempting to travel in the same direction hold the balance of the system in check and keep it cold. As it is often necessary to arrange mains in this way and sometimes impossible to arrange them in any other way it is very desirable that there should be a remedy for this trouble, and I have found that the best and surest preventive was to take the connections for the near radiators, or for all the radiators and connections, from the side instead of from the top of the flow and return mains, thus retarding the flow through the near connections, assisting the flow to the extreme end, and making a uniform circulation through the entire main and system.

I designed an apparatus in this way some time ago where the main was over 300 feet long, and with the water at the heater at 130 degrees F. the temperature of the water at the extreme end was 120 degrees, while with a higher temperature of water at the heater the difference was less, until at 180 degrees the difference was only five degrees. I mention this to show that with a proper arrangement of branch connections and a suitable size of main it is possible to circulate water through a continuously rising horizontal main for long distances at a comparatively uniform temperature.

Where this system of mains is used and it is found desirable or necessary to supply indirect radiation or to locate radiation in the basement I have found it to be an advantage to use a separate main, either arranged with a syphon extending to the ceiling of the first floor or by increasing it in area, doing away with the syphon and dropping from a high point above the heater to the radiation and returning at or below the floor line, in either case carrying an air pipe from the highest point to the expansion pipe or expansion tank.

Some engineers have recommended a continuous circulating main rising to the highest point immediately above the heater and falling around the basement, usually near the outside walls and connecting with the return opening of the heater, the branch flow connections being taken from the top of this main and the return connections being taken into the side of the same main, this arrangement possibly being suggested by the continuous circulation in a one-pipe steam system which it resembles. The objection to this system in hot water heating is that while in steam above atmospheric pressure there is uniform distribution and temperature, in a hot water system, the circulation being dependent on a loss of temperature which in actual practice varies from ten to 40 degrees and which is usually over 20 degrees, radiation figured at a uniform ratio for cubical contents, wall, and glass exposure, will heat to different temperatures at different points in the main, making it necessary to plan the arrangement of the main before proportioning the radiating

surface, any change in the main affecting the temperature of the surface. I have used this arrangement of flow main where the system was about half direct and half indirect radiation, taking all the branches from the side of the main, falling to the indirect stacks and rising to the radiators, but using a separate return at the ceiling for the direct radiation and a return at or below the floor line from the indirect radiation; this arrangement prevents the cooling of the flow main and permits a uniform circulation and temperature at all points.

The overhead system, where practical or permissible, has some advantages, doing away with separate return risers and permitting the use of a smaller area of main for a given amount of radiation, and while the temperature of the water on the lower floors with this system is lower than on those above, radiation can be figured uniformly on any floor with a certainty of a uniform temperature and a positive knowledge as to results.

The usual practice in placing this system has been to carry the horizontal distributing mains at or below the ceiling of the upper floor, falling to all the radiation and rising to the expansion tank, but I have found that this arrangement, on account of the limited height above the main for placing the tank, made it possible to throw sufficient water out of the main, lose it by evaporation or pass it off in steam, as to stop the entire circulation, and while an automatic supply would prevent this, it is not always possible to obtain pressure at this height and so I have found it to be an advantage to place the horizontal mains on the ceiling below the highest floor on which radiation is desired, either carrying separate returns from the upper floor radiation or, when there was not a great amount of it, returning it into the side of the horizontal main. This arrangement gives ample room above the mains and radiators for placing the tank and ensures the system or at least the mains being free from air, full of water, and in operation at all times when fired.

I have found the proper average proportion of area in mains for the ordinary rising main system to be one square inch in area for each 100 square feet of radiation and for the overhead system, 25 per cent less, increasing the area in either case in long runs to overcome friction and to insure a uniform circulation.

## DISCUSSION.

Mr. Barron:—I think Mr. Mackay has, in a measure, condensed the important matters of which this paper treats, leaving nothing to be desired. It is a mistake for Mr. Mackay to try to cover the history of hot water heating in a paper of this character. The work he refers to as that of Mr. Bramah, 1836, is really Mr. Thos. Tredgold's work

of 1824. T. Bramah published this work in 1836 with an appendix on hot water, Tredgold having previously published three editions. What Bramah did was to advocate hot water in place of steam. Tredgold had preferred steam. I do not think the sizes given by Richardson are smaller than used in the "Perkins" system to-day. I cannot see that there is any danger in large mains if they are properly proportioned. Mr. Newton, of Bartlett, Hayward & Co., has put in mains up to, I think, 30 inches diameter, and he does not seem to have feared internal circulation. When Mr. Mackay says that the natural tendency of water to return in the return main is to travel toward the end of main instead of returning to the heater, I think he falls into a serious error, as two columns of water at about the same temperature cannot travel together without their temperature becoming the same, as water is a most excellent conductor of heat. The Gulf stream is not an exception. I do not believe that this accounts for the stagnation in the system that he refers to. I am surprised that Mr. Mackay should use the same proportion of pipe for hot water heating as is generally used for low pressure steam heating, but I think in this he is correct.

In hot water pipe the proportion of the sizes have been reached by experiments, and their sizes should agree with theoretical deductions. If a system of main pipes should be laid out starting from boiler with six inches diameter, both flow and return, it would seem to me to be desirable to make one 8-inch pipe do the work of the two 6-inch pipes by laying out the pipe on the single or continuous main system. To my mind that system is ideal for hot water circulation, and as the amount of surface exposed to losses from main radiation is lessened, I am surprised this system has not taken a firmer hold on those who erect hot water apparatus. I am inclined to think that discussion of hot water proportions are apt to be unprofitable, because of the fact that hot water work is not in public favor, and that engineers and architects have largely come to hold the opinion that the future field of usefulness for hot water heating is going to be very limited, and that, except for very small units, it is not as economical a form of distributing heat as the gravity steam system. I merely give my own point of view; I will be glad to know that I may be mistaken. I am afraid that unless the hot water specialists very soon develop some form of high temperature hot water apparatus that will be an improvement over the ordinary hot water systems by low temperature, we are merely wasting our time discussing the forms and proportions of apparatus that is of no further interest. It will not do for gentlemen to argue that hot water has such peculiar merits that it will always be preferred in face

of our common knowledge that the special hot water industry is making no headway, and, unless appearances are deceptive, is declining rapidly. I feel sure that there is not one-half the hot water work now being done in this country that there was five years ago, and this is particularly true if you take the volume of work done in dollars and cents; the erection of very large hot water plants has practically ceased; they are not economical investments, and the new conditions in large units, where light, heat, ventilation, and power become part of one problem, have put the consideration of hot water work out of the question with progressive engineers or architects. The limitations of hot water heating under modern conditions are clearly marked if we take such an example as the St. Paul Building, when, if we heated it with a hot water pumping system, using either a double action or centrifugal pump and heating the hot water with exhaust steam, we should have a static pressure or head in this 25-story building of at least 150 pounds pressure. I hardly think anyone will claim that hot water heating under these circumstances would be either feasible or economical, although I am willing to admit that under favorable conditions the relative economy of hot water or steam as agents for heat distribution is not worth talking about.

Mr. Connolly:—When Mr. Barron states that hot water heating for residence and office work is on the wane, I take direct issue with him, and state that it is continually growing; that during the past five years it has grown from swaddling clothes until it is a very healthy youth at the present day.

Resuming the consideration of Mr. Mackay's paper, about the middle of the last paragraph, page 117, he says: "While it is claimed that it is impossible to hold cold water above hot water in a hot water system, it is possible in this case and in any case where, on account of a larger main and a free circulation through the radiators and risers near the heater, the water is allowed to enter the return main near the heater at, say, five or ten degrees lower than the temperature of the flow main." In looking over the paper that Mr. Bolton is to submit this evening, in the last paragraph on page 155 he speaks of condensed water in pipes. He says: "At this point it may be instructive to point out that the common theory of the flow of condensed water in pipes is largely in error. It is usually assumed to be drifted along at the bottom of the pipe, while a visual study of the actual effect in a glass tube will show that it is propelled all around the interior surface, the effect of gravity being sensibly smaller than that due to capillary adhesion." Now, there are two diametrically opposite assertions in Mr. Bolton's and Mr. Mackay's

papers in regard to the flow of water; and on page 12 of Hood's book it is stated that where heat is imparted to the water a dilation of the volume of water takes place, the lighter particles rising upwards through the colder ones. I would naturally think that would be through the center of a vertical pipe, and would bear out the capillary adhesion that Mr. Bolton speaks of when taken in connection with the outside cooling surface of the pipe, and I presume Mr. Mackay is in error in regard to that point.

There are one or two other things in respect to Mr. Mackay's paper. He states that he prefers four mains in one instance in lieu of one main. I must disagree with him on that. He also reports that he saw a piece of work where a main pipe was 180 feet long, and at the extreme end it was cold, and that it would be overcome by two mains 90 feet each. It would be strange to have a main 300 feet long rising gradually from the boiler and get it to circulate at a maximum loss of only ten degrees, and yet advocate dividing this 180 foot main into two equal parts. That is one point I should like to ask Mr. Mackay. Was this main 300 feet long of one size, or was it reduced gradually?

Mr. Mackay:—It was reduced as the connections were taken off, but not at every connection. The end of it was about three inches or less.

Mr. Connolly:—I cannot agree with Mr. Mackay where he states that on indirect work he uses a separate flow main and runs it overhead or constructs a siphon for indirect work. This, I know, is entirely useless. He seems to have the right idea on the 1-pipe hot water job, and I know that the same thing is applicable to a 2-pipe hot water job that he uses with a 1-pipe system, the branches falling to indirect and raising to direct. I agree with him fully on the 1-pipe, but differ with him when he states that he requires two returns. This is all I have to say on this paper. However, I am going to rise at every opportunity when a gentleman states, as Mr. Barron did a moment ago, that hot water heating has received its death blow. On the other hand, it has burst forth from the cerements of the grave, and is the liveliest corpse that is in existence at the present time.

Mr. Cary:—Mr. Barron made a statement a few moments ago to which I would take exception. He spoke of water being an excellent conductor of heat. A good many are very familiar with the old laboratory experiment in which a test tube is taken and water is frozen in it and ice remains at the bottom. The tube is inclined in this direction (illustrating) and heat from a gas burner is applied to the upper part of the water. The upper surface of the water would

boil for a long time without affecting the ice which remains at the bottom. Water is a very poor conductor of heat instead of being a good conductor.

Mr. Barron:—Allow me to ask, What kind of a man applies heat to the top of water?

Mr. Cary:—I was merely illustrating how poor a conductor of heat water is, and I think that is as good an illustration as can be shown.

Mr. Hopkins:—I am inclined to think that the hot water heating men of the country have been largely in error in regard to what causes circulation of water, and because of the ignorance upon that point the greater number of the errors that have been committed on the subject can be traced. Mr. Barron has referred to Mr. Newton, of Bartlett, Hayward & Company, who, as perhaps most of you know, has had perhaps the greatest experience in this country in hot water heating. He certainly handled the largest work, not only in this country, but in the world, and in dollars and cents perhaps more than all others here. Some years ago, when the trustees of the Johns-Hopkins hospital building contemplated going ahead under the provisions of a will, they consulted with Bartlett, Hayward & Co. in regard to heating and ventilating apparatus. They at that time recommended hot water for various reasons and prepared a set of plans and specifications for the trustees, the idea at that time being to submit them to general competition. The trustees, for some reason—I do not know what it was now—sent those plans and specifications out around the country to some half a dozen experts for criticism. There was only one man who attempted to criticise them to any extent and he pronounced that the work would be an entire failure if carried out. He went on to prove by indisputable figures that, taking the extent of the circuit, which would be about 6,000 feet on the longest run—3,000 feet out and back—that with a small head, for the job was an indirect job with indirect stacks practically upon a level with the tops of the boilers, he figured it out that the job would come practically to a stand still; for, as he presented his figures, it would take some 72 or 73 hours for the water to circulate to the extremity of the system and back again, and of course it would be practically worthless, as in 72 or 73 hours the water would get too cool. The trustees, with Surgeon General Billings, were very much alarmed and they came to Bartlett, Hayward & Company with their fears and with these criticisms, and one of them wanted them to rearrange their plans and convert them into a steam apparatus. Mr. Newton simply informed them that Bartlett, Hayward & Company understood their business and that they stood ready to

give bonds secured by half a million dollars of Baltimore real estate that the apparatus would work. In view of the adverse criticism the trustees decided to give them the work by the day. To prove the correctness of their position and the incorrectness of the critics, when the work was practically completed, tested, etc., they tapped into the main, put in a nipple and a glass bulls-eye connected on to the main flow near the boiler. With a hand pump they pumped in coloring matter with all connections into the indirects shut off so as to prevent any by-passes. They took their observations and found that it only took about 21 or 22 minutes for the water to circulate to the extremity of the system and back again. Of course it was not a perfect test, for the reason that conditions would have been different if all the indirects had been on and working. The figures that the critic had presented were entirely correct. He had taken his head and his friction into consideration. But his premises were wrong, for he had simply assumed that the circulation of water in the apparatus would be due to the difference in specific gravity between two columns of water; while Mr. Newton simply assumed, and has proved that the circulation of water was due to the expansive force of steam—millions of globules of steam form on the surface of the boiler that tend to shove the water along. Now Mr. Newton's plan of laying out a heating apparatus is this: He does not care what the size of connection to the radiator is so long as he takes a unit. I have known of work he has put up where there were 300 or 400 feet of heating surface with a coil radiator. The only thing Mr. Newton does is to keep the proportion of his branches equal to the areas of his main and then, putting the boiler behind it, he pushes the water around, as though it was a steam pump behind it.

Mr. Kent:—I should like to ask what the temperature of the water was in that case at Johns-Hopkins?

Mr. Hopkins:—At the time that the test was started the water was in the neighborhood of 160 degrees, if I remember correctly.

Mr. Kent:—How did they find these millions of globules of steam at that temperature, when steam does not exist below 212?

Mr. Hopkins:—My dear sir, globules of steam will form on heating surfaces; if they do not exist but for a second of time, they exist.

Mr. Kent:—They exist below 212 degrees?

Mr. Hopkins:—Understand these globules of steam were formed upon the *surface* of the boiler.

Mr. Kent:—How can that make water go forward in the pipe so many feet?

Mr. Hopkins:—For the simple reason that as they form there there is an expansive force. They exist but for the thousandth part of a second, perhaps, but they exist.

The President:—I should like to ask Mr. Hopkins if he stated in this discussion the actual length of main pipe?

Mr. Hopkins:—My recollection is that the total circuit was in the neighborhood of 6,000 feet. There were a number of buildings on one plant, you understand.

Mr. Barron:—I think a full description of that work was published at the time in the Engineering Record, and I think it is in Dr. Billings' work also. But this explosive globule of water is something entirely new to me. I hope Mr. Kent will elaborate that. I never heard of it before. Some one ought to get credit for the discovery, if it is new.

Mr. Mackay:—I want to state that my paper was written solely in reference to open tank hot water heating apparatus. I merely mention this in case some questions may be asked in reference to it which would refer to the high pressure system. My paper records my practice and the practice I have seen and which I recommend in connection with a low pressure system.

Mr. Hopkins:—I might perhaps help Mr. Kent out a little. One illustration that Mr. Newton gave to me—I had been associated with them for some years—was this, that when heat is applied to the heating surface of a vessel in which water is contained globules of steam are formed, the number of globules increasing with the intensity of the heat applied, and of course with that increase in the intensity of the heat the temperature of the water will naturally rise. He illustrated it to me in this way: If you take a plain old fashioned green house job of 4-inch pipe, with an expansion tank at one end and a boiler at the other, and you take the water at a given temperature, say, 100 degrees in the flow and 80 degrees in the return; take the velocity of the water under those conditions at those temperatures, that if you increase the temperature the flow of water increases as you increase the temperature. When you get to 200 degrees, with the same comparative difference in the temperatures of flow and return, the velocity of your water is very much greater—I forget the figures now, it is so long ago. But it is all very interesting. At some future time I might be able to give it to you in detail. But his explanation was that with the increase of the temperature and the intensity of the fire applied, there were some steam globules, and, as a consequence, a greater expansive force, and the water was pushed with greater rapidity. Now there was the same comparative difference in temperatures between your flow and your return. If the difference in specific gravity is accountable for the circulation of water the velocity of the water would be the same. No matter whether it is 100 degrees or 50 degrees or 200 degrees, as long as there is the same

difference of temperature between the two columns, the flow should be the same. But increase the temperature by increasing the fire applied to the heating surfaces and you will find the velocity of the flow is increased.

Mr. Kent:—Mr. President, this is a very important new theory. I should like to know if it is treated of in any of the standard works on heating.

Mr. Connolly:—It is not a theory, Mr. Kent, it is practice.

Mr. Hopkins:—I would say that I have had talks, a number of times, with Mr. Newton on the advisability of his writing a work on heating, giving the results of his experience, experiments, etc., and his remark to me was that any man who thoroughly understood the subject of heating and ventilation could make a good deal more money out of it by doing something else than writing a book about it.

Mr. Kent:—I hope the gentleman himself will undertake to write a paper on the subject. If it has not been published anywhere, I wish he would write a paper about it, so that we can study it at our leisure.

Mr. Hopkins:—As you might know, Mr. Newton is a very quiet man, and while I know he has the interests of the business very much at heart and is with us in spirit and all that, yet being of such a retiring disposition he declined the honor of being president of this society. He is a man who has never gone into print and has never attempted to promulgate his views. But if you meet him personally and ask for his experience, he will be most pleased to give it to you, and in a persuasive way and with such proofs that you would be thoroughly convinced. I would say that my own practice has proved his theory to be correct, for, after a loss of dollars and cents, I have followed out his views in many instances and found them correct.

Mr. Kent:—The gentleman misunderstands me. I did not mean to ask Mr. Newton to write a paper, but to ask the gentleman himself to write a paper explaining this theory, or practice, as one gentleman calls it, so that we can study it. I think it is his duty to the society to make this thing clear.

Mr. Hopkins:—I should be pleased to do that at some future time. By looking up the data that I have I could give you details which I cannot now recall.

Mr. Wolfe:—Can't we prove this whole theory very simply? Don't we know that in many of the manufactures we boil water with steam? As I understand the theory, the water against that surface generates steam in very small particles and the water naturally condenses them and takes up their heat until it arrives at a temperature of 212 degrees and boils. We all know that in many of the arts they put in a steam coil and from the steam coil they boil water and gen-

erate steam. Is not that the pushing principle to which you refer? You push it through the pipe all right. You can produce power from steam by raising the temperature of water and thereby gain pressure; you do not depend simply on the circulating power or the pushing power, as the gentleman describes it.

Mr. Cary:—The matter of circulation of water is one that I have been obliged to study somewhat. I think an erroneous idea generally exists on the subject, and it has been put forward by some of the brightest men in this country. One stated that circulation in a U tube, for instance, a tube of glass in the shape of a letter U, was caused by the difference in weight of the water in the two legs of the U tube; in one we had globules of steam rising, and he took the weight of the steam and water together and balanced against that the column of the water in the other side, which had no steam in it at all. In other words, he considered the steam and water as being one liquid. That is not the case. Where steam is being formed in water, you must consider two fluids, considering gas as a fluid, which is perfectly proper—you must consider two fluids existing, one the steam, and the other the water. Now, they each have their individual circulation. There is a slight circulation caused by the steam rising in the water. But that is merely an induced circulation. As it passes up with the water it carries a current of water along with it. You might produce the same effect by putting a lot of corks in the bottom of a vessel of water and allow them to ascend, and as they ascend and push the water away they cause the water to flow upward slightly. It is the difference in the weight between the column of water in each of the legs of the U tube that causes the circulation, and the steam has very little to do with that. As far as the formation of bubbles on the side of vessels where steam is generated below 212 degrees is concerned, most people who have had experience in that line know that water contains more or less air and other gases. These gases are the first to appear on the side of the vessel, and that is all that we get until we reach the boiling point, which is determined by the pressure, and then the steam commences to form. The steam has a separate flow, you might say, of course inducing a slight flow of the water, but very little, and the circulation of the water itself is due entirely to the difference of head in the two legs.

Prof. Carpenter:—If I am not interrupting, I should like to say a word or two on this subject, and I must say that I am inclined to side with Mr. Hopkins to a certain extent on this last discussion, because I have known of water tube heaters of peculiar construction in which there was evidently a large formation of steam close to the fire and sufficient to produce a very large acceleration of the water.

I call to mind one particular case where I was able to eject water a distance of 20 feet out of a hot water heater; it would fly out just like a geyser. The water itself was not heated very greatly, and the result was certainly due to the formation of steam in the lower part of the heater, due to the peculiar construction of the boiler. I think, on the other hand, that the difference of opinion is due to the fact that you are talking about different forms of heaters; that with a great many heaters it is impossible to produce this action; and I am, on the other hand, very certain that steam is sometimes generated over the fire-box in sufficient quantities to materially affect the circulation. By the way, I will say that I mentioned the fact in my book on "Heating and Ventilating Buildings," consequently I think that what Mr. Hopkins says is true. It would seem, however, that the theoretical flow which we might have from natural causes, particularly in the case of which Mr. Hopkins speaks, accounts for nearly all of the circulation which was obtained; if we might neglect friction, and friction is very light indeed in hot water circulation, because the flow is so small, we might have a velocity which would bring the water back at nearly the velocity stated. In such a case it might be explained from natural causes. The other case was spoken of as a possible explanation, and such cases are not rare. I once set a hot water heater in a certain college building which later developed a very bad habit of ejecting its water and frequently at inconvenient times. I have known that particular heater to throw the water nearly out of the system at the expansion tank so as to wet the upper portions of the building and alarm everybody; the water thrown out would not be heated very greatly, indicating that in some part of the boiler steam had formed to a very great extent, and this acted to throw the water out from the boiler. Such action would account for the case which Mr. Hopkins describes.

Mr. Blackmore:—The case that Prof. Carpenter has just spoken of clearly points toward defective circulation. It may be in the heater or it may be in the system. It is a well known fact that steam will push, as Mr. Hopkins says, under certain conditions. It is a well known fact that if steam is allowed to be generated in a heater it will escape toward the line of least resistance. If that happens to be to an expansion tank, the expansion tank will boil over, even though some of the radiators on the system may not be circulating at all. On such a system if the expansion pipe is closed up and the expansion tank put on the noncirculating radiator, immediately that radiator will circulate. Why? Because the only point towards which steam could escape is at the opening at the expansion tank. Now, the line of least resistance is toward where that expansion tank is,

and that is where it will boil over. But a hot water heating apparatus should not be considered under those conditions, as they are defective conditions. A hot water apparatus should never have steam in any part of the system and it should circulate, to get economical results, at a temperature not higher that 180 degrees. If the heater is constructed properly and the piping arrangement, to provide for friction and the valves, etc., is properly proportioned, it ought to circulate throughout the system pretty uniformly. If the boiler is arranged so that every particle of water can escape through it as rapidly as it is heated, manifestly steam cannot be formed. If the system is also arranged so that heat will be taken uniformly from the heater as rapidly as generated, steam cannot be formed in the system. The difference in the friction would be very readily determined by the amount of heat in each one of the radiators or by the temperature taken at the air valve. If that ran uniformly it would indicate that the friction was well taken care of. Prof. Carpenter made the assertion that the friction was small in a hot water apparatus. That needs to be qualified a good deal by the distance you are running with your main. In an ordinary house, 35 or 40 feet square, friction is very small and scarcely needs to be taken account of, but it does need to be taken account of in long lines. All sorts of devices have been adopted to throttle the connections that are taken off near the boiler to help those at a distance. Unfortunately, I did not hear the opening of the discussion, but in the paper here mention is made of a main 300 feet long. "And with the water at the heater at 130 degrees the temperature of the water at the extreme end was 120 degrees, while with a higher temperature of water at the heater the difference was less, until at 180 degrees, the difference was only five degrees." Now it is commonly supposed that the hotter a thing is the more heat it will lose. But this would indicate that the hotter we get it the less heat is lost, the additional velocity gained by the higher temperature more than compensating for the extra amount of heat radiated. I should like to hear some other experience on that. It hardly coincides with my practice. I have generally found that the higher the temperature we get in the heater the greater is the loss between the flow and the return.

Mr. Barron:—There seems to be a misunderstanding with respect to Mr. Hopkins' explanation of this theory of Mr. Newton's. I do not know of any other man with whom I have talked on the subject who talks more intelligently on hot water than Mr. Hopkins. I think we have lost sight of what he says—that the globules of steam formed on the hot surface of the boiler (let us say it is a horizontal tubular boiler)—push the water along. They form

below the boiling temperature of the water above them. They form under a certain pressure due to the height or the head of the water. We have no data on subjects of this kind and we ought to receive them with respect when it comes from a source that deserves respect. When it comes from a source such as Mr. Newton, a man certainly of very large experience, I think it is worth considering. I do not believe it myself. I do not believe it can be possible. But it is well worthy of your investigation and discussion.

Mr. Gormly:—Before this discussion is closed I should like to say a word or two in relation to it. I have been erecting water heating apparatus for 25 years. I have been a fairly close observer during all that time, and I feel to-day that I know less than I thought I did when I started in business. I have noticed that something more than a difference in gravity of two columns of water aids the circulation in a heating plant. Whether it be steam, or gas, or air, whatever it is, it accelerates the movement of water under certain conditions. In my own office on several occasions I have opened the air valve on the radiators and have set fire to something coming out of the valves. Whether it was gas, or air, or steam, whatever it was, it took fire, and those radiators have been in use with the same water in them for seven years. I can set fire to-day to the gas that escapes from the radiators when I open them. It has a peculiar smell when escaping. At first I thought it might be attributed to the oil which remained in the pipes and radiators in the construction. I do not believe it would last there for seven years. I have in mind a steam job which was placed in West Philadelphia in a large dwelling house. The pipes were very small, and because of the poor system of construction, having no water line, it pocketed air in many places, many of the radiators did not heat at all, and it was a failure as a steam job. A friend of mine was called in to remedy the defects in the steam job and recommended that it be turned into a water circulating plant. This was done without changing the system or radiation or piping. To my surprise, and much to the surprise of the party making the change, that defective steam job made a first class water job, although the mains were too small to work successfully with steam. There is something in that job to make the water circulate so swiftly in pipes which proved to be too small for steam.

I will call your attention to another case where I am circulating water in 400 feet of radiation through a 1¼-inch flow and return main with first class results. Under ordinary conditions this would be an impossibility. One of the gentlemen who preceded me remarked that you cannot hold cold water above hot water, that it will fall to the position which its density will justify, in a water system. My own

experience is that cold water will at times stay above hot water and stay there persistently, all theory to the contrary notwithstanding.

I had a case in New York, at Seventy-ninth street and Ninth avenue, where we fitted a dwelling of four stories with water radiation. When we started our fire we had one radiator refusing to circulate, although there was hot water above it and hot water below it. The temperature of the water both above and below that radiator was 200 degrees, yet the radiator remained cold and the cold water stood where theory said it could not stay. It persistently refused to circulate. We had to carry a separate main from the heater to that radiator, then it would not circulate until we ran a separate return back to the heater and made a separate circuit for that one radiator. Let me here say for the benefit of those who may run against such a snag, that they can save the cost of two mains, in a case of this kind, if they will run their return from such a radiator into their flow pipe. This I discovered later. I have carried the return into the flow pipe many times since and always with the best results.

A siphon as an aid to circulation has been spoken of. My experience with a siphon has not been successful. On a water job in Germantown, which was completed according to the original intention and which was a success in every way, the owner decided to add to the plant a coil radiator in a vestibule. We located a 1¼-inch coil and tapped the nearest flow and return pipes in the basement. When we opened our valve to start the flow, the coil heated beautifully, but the circulation was from the return to the flow, making the bottom of the coil the hottest.

Our client was one of those genial souls who insist upon having everything right when it costs them nothing. He admitted the coil was a success as a heat transmitting medium, but he knew it should have circulated the other way, and insisted on having it made to do so. We were full of the siphon theory about that time, and ran a siphon to the ceiling, about 15 feet, and down to the radiator or coil. We demonstrated two things, that a siphon won't always siphon, and that cold water won't always fall below hot water. The siphon did no good and the coil circulated backward. Our genial client persisting, we did more thinking that afternoon than we ever did before in a like case. The result was that we carried our return into our flow pipe, and, as the story says, "lived happily ever after." The most successful plants we have are built with a flow pipe which rises at the heater, gradually descends, and, in the descent, goes around the building, the branches to all radiators, both flow and return, being taken out of that circuit. The only objection we have to it is that toward the low end of the circuit the water becomes cooler, and we

are compelled to place more radiation on that end than we would on separate circuits. On this system we have never had a radiator fail to circulate.

Mr. Barron:—That continuous motion that Mr. Gormly mentions was shown in the old English works. Mr. Bates, in his paper before the National Association of Master Steam and Hot Water Fitters, a few years ago, gave a description of the heating of his house, in which there was hot water on the ground floor and a combination system above, and it worked very satisfactorily. I had occasion to connect returns from a number of riser lines to radiators below the water level and I obtained splendid results. I got a combination of hot water and steam systems.

Mr. Mackay:—I have made memoranda of some of the remarks made by the various gentlemen who have spoken on the subject treated in my paper. In answer to Mr. Barron's remarks as to the heating of the St. Paul Building by hot water heated by exhaust steam, I would not put in an apparatus where I would heat the water in the basement. That is, I would not put my apparatus in the basement of that building and carry the pressure of water from the bottom to the top of the building. I think it is possible not to have any more pressure on the system in that building than you would have in a three or four story building by merely arranging it in sections and heating the water at different levels. If it were a question of considering hot water in such a building, it would have to be considered in that way. I have not advocated hot water for any particular building in my paper. I am not here as an exponent of hot water heating. I merely tried to keep away from the question of boiler construction when I was requested to write a paper on the subject, and I hit on the mains as being a subject that might help some one out without hurting anybody's feelings. In large mains my experience has been that there is an internal circulation; that there is a difference in temperature between the top and the bottom of the main in an ordinary hot water apparatus. In an ordinary low pressure, gravity, hot water apparatus there is a large difference. You can find five to ten degrees difference between the top and the bottom of a main under certain conditions. I have had experience in applying large mains of cast iron with flanges. The expansion and difference in temperature were so great that the flanges were broken off. I believe that in those large mains that Mr. Newton has put in it was the strength and elasticity of the material used in the mains that prevented the same thing that happened to me with cast iron mains, which had to be overcome by an expansion joint or something that would give and take enough to take up that difference in the expansion.

The circulation spoken of by Mr. Connolly could have been carried with a main 180 feet long by changing the branch connections to the near runs. But while the near runs take the majority of the water heat and bring it back into the return, the difference in temperature was overcome by the friction, and consequently the apparatus did stand still and is standing still to-day. When you run it to a very high temperature (which I do not consider good practice) you can get circulation in every part of the main. But when they are running at low temperatures they cannot get that circulation at the extreme end. Uniform circulation in the main 300 feet long was not due to the size or length of the main or anything of that sort, but it was due to the way that the connections were taken off.

Mr. Blackmore asks the reason why at higher temperatures the temperature is higher at the extreme end. I can explain it in this particular case in this way: the mains were not wrapped. They were used for the heating of the basement of the building. I believe that if those mains had been wrapped (if there was no necessity for their being used for heating that basement) the conditions would be exactly as Mr. Blackmore states under a rise in temperature.

Mr. Connolly also mentioned that he does not agree with me in stating that if the boiler were located at a central point and the radiation were required in four different directions, four separate mains would be better than one. He claims that one main would be best. I think he made that statement under a wrong impression of the conditions. Then, in connection with a separate main for indirect work, or the reason for rising up and falling down for my indirect radiation, my reason for it has been this, that in running an ordinary hot water apparatus sometimes at low temperature the radiators above will rob your stacks, which are the most important part of your heating apparatus; but with separate mains arranged in that way the separate amount of the water entering each main must go the circuit of the main, and if part is going to the direct and part to the indirect you are getting a uniform circulation and radiation at all points.

Mr. Connolly:—You said, Mr. Mackay, in another part of the paper that you ran down to the indirect stacks in the 1-pipe system. If you do that and get good results from it, why wouldn't it be applicable to the 2-pipe system?

Mr. Mackay:—That is a special arrangement and not my regular practice. I have done that. In cases where the boiler is large it is possible to supply both direct and indirect from the same main and get a uniform result. In most cases (that is where part of the trouble is) the boiler is too small. As a result, the natural tendency of water being to rise, whatever the cause of circulation is, it would rise to the

highest point—the steam if generated would rise to the top and not fall to the bottom.

In connection with the steam and water raising a geyser, as Prof. Carpenter said, I believe that is possible in an apparatus where the grate surface is out of all proportion to the boiler surface and that you partly throw your water off your surface in steam. But it is not possible in a properly designed and constructed low pressure hot water boiler where you have an internal circulation and where it is almost impossible to raise the water off the surface no matter what temperature you may raise it to—even above the boiling point.

Referring to the case of which Mr. Gormly speaks I consider that it was a water gas caused by the air being expelled from the water and gathering at the highest point of the system; it is the continual expelling of the air from the water, whether the water has been in the system several years or changed every year.

Mr. Connolly:—He said it was not from the oil.

Mr. Mackay:—My experience has been that changing of water helps the heating of the apparatus. In connection with the amount of radiation that Mr. Gormly has been able to take care of with a 1-inch water main—of course that is a special case.

Mr. Connolly:—I want to ask Mr. Gormly if that job he spoke of was on the open tank or closed tank system? Also, in regard to the job that was imperfect as regards steam, but was one of the most successful hot water jobs he had ever seen. I should like to know whether that was open tank or closed tank.

Mr. Gormly:—Working under 30 pounds pressure.

Mr. Mackay:—I have found that a siphon has helped circulation in just such cases as I have mentioned; that you can get the same results by enlarging your basement main and running it exactly as you would a 2-pipe system. In regard to Mr. Gormly's statement that he has found the continuous circulating main around the basement to be the best application of hot water heating, I have to differ with him in that. He states that he finds the same trouble with it that I do, but still considers it the best. My experience has been that the best operating arrangement of mains for hot water heating is where you carry up to the under side of the ceiling on the top floor on which you want radiation and drop down. I find you can do better work through smaller mains and be certain of more positive results.

# XXIX.

## RELATIVE EFFICIENCY OF VENTILATION BY A CHIMNEY AND BY A FAN.

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(Member of the Society.)

The relative efficiency of ventilation whether obtained by a heated chimney or by mechanical means, as, for instance, by using a fan, can be determined quite accurately by calculation in part and by reference to experiments which have been made relating to the efficiency of fans and engines.

FIRST, THE EFFICIENCY OF VENTILATION BY A HEATED CHIMNEY.—In such a case the flow of air is produced by a rarification in the chimney due to the heat and the consequent unbalanced pressure of the atmospheric air from the outside. The velocity of the air discharged from the chimney is computed in various places and is given by the following formula:

$$V = \sqrt{\frac{2gha\,(t' - t)}{1 + at}} = \sqrt{\frac{2gh\,(t' - t)}{460 + t}} = \sqrt{\frac{2gh\,(T' - T)^*}{T}} \quad (1)$$

In the above formula h is the height of the chimney in feet, t′ the temperature of the air in the chimney, t the temperature of the outside air, a the coefficient of expansion of air for one degree, which is equal to 1 divided by 460; 460 + t is equal to the absolute temperature of the outside air as represented by T, and 460 + t′ is the absolute temperature on the inside of the chimney as represented by T′; g, the accelerating force of gravity is equal to 32.16. From the above formula we can readily calculate the velocity of admission of the cold air into the chimney which will be inversely proportional to its volume and consequently will be equal to the velocity of discharge as given in formula (1) multiplied by

$$\frac{1 + at}{1 + at'} = \frac{T}{T'}$$

Furthermore, let Q equal the total heat used to warm the air in heat units, c the specific heat of air, equal to 0.238, P the total weight of

*See Carpenter's Heating and Ventilating Buildings, page 44.

air passing through the chimney in a given time. Since the weight of air multiplied by the specific heat and this product by the difference in temperature is equal to the total heat supplied in heat units, we have

$$Q = Pc\,(T' - T)$$

from which, by transposing, we have

$$P = \frac{Q}{c\,(T' - T)} \tag{2}$$

The mechanical work done in each case is evidently to be obtained by multiplying the weight by the square of velocity divided by twice the accelerating force due to gravity (2g). From formula (1)

$$\frac{V^2}{2g} = \frac{h\,(T' - T)}{T} \tag{3}$$

Multiplying equations (2) and (3) together we shall have the mechanical work in foot pounds required to discharge the air, neglecting friction.

$$W_d = \frac{PV^2}{2g} = \frac{Qh}{cT} \tag{4}$$

Had the chimney been perfect all the heat would have been converted into mechanical work, in which case we should have had 778 foot pounds of work for every unit of heat expended, or, as a condition of perfect utilization of heat,

$$W_p = 778\,Q \tag{5}$$

The efficiency of the chimney must be the value in equation (4) divided by that in equation (5)

$$E = \frac{W_d}{W_p} = \frac{\;\frac{Qh}{cT}\;}{778Q} = \frac{h}{778cT} = \frac{h}{185.2T} \tag{6}$$

When the temperature of the outside air is 60 degrees the absolute temperature T is 560 and for that temperature the efficiency

$$E = \frac{h}{96304} \tag{7}$$

From this discussion it is noted (see equation 4) that by the application of a given amount of heat the useful work done in discharging air from a chimney varies directly as the height of the chimney and inversely as the absolute temperature of the outside air. This has been pointed out by a previous writer,* although the demonstration given in this case has been essentially different; furthermore, it should be noted that this statement applies to the work done

*See paper by Prof. Trowbridge, Vol. VII. Transactions American Society Mechanical Engineers.

in delivering air from the chimney only and not to the more important case of delivery of air to the chimney.

By noting the result in equation (7) it will be seen that the efficiency of discharge when the temperature of the external air is 60 degrees is equal to the height of the chimney divided by 96304.

This of course signifies that if we had a chimney 96304 feet in height all of the heat expended would be utilized in the mechanical work of discharging the air from the chimney, but for all other cases the amount of heat utilized would be less and in proportion to the height of the chimney.

The preceding discussion relates entirely to the work done in discharging the heated air from the chimney; this is essentially different from that required for the delivery of cold air to the chimney, and this case will be considered separately, since it is of great importance in connection with ventilation.

The velocity of cold air entering the chimney will be equal, for the reasons previously given, to

$$V' = \frac{V\,T}{T'} = \frac{T}{T'}\sqrt{\frac{2gh\,(T' - T)}{T}} \tag{8}$$

from which

$$\frac{V'^2}{2g} = \frac{hT}{T'^2}(T' - T)$$

The work in foot pounds per second will be found by multiplying the above value by that given in equation (2) giving

$$W_c = \frac{P\,V'^2}{2g} = \frac{QhT}{cT'^2} \tag{9}$$

The above equation gives the useful work which is performed in delivering the cold air into the chimney, and in this case the results are seen to depend on the absolute temperature inside as well as outside and also on the height.

The efficiency for this condition is determined by dividing formula (9) by formula (5) in which case we have

$$E_c = \frac{W_c}{W_p} = \frac{\frac{QhT}{cT'^2}}{778Q} = \frac{hT}{778cT'^2} \tag{10}$$

In order to utilize all the heat in mechanical work of moving the air the height will in this case be somewhat greater than in the preceding case considered, since the results are affected somewhat by the internal temperature of the chimney.

It will be noted, whether the work be performed in discharging the air from the chimney or in delivering the air to the chimney,

that for all ordinary cases and temperatures the efficiency is exceedingly low, or, in other words, that direct application of heat is not an economical way of moving air.

SECOND, THE EFFICIENCY OF FANS AND BLOWERS.—Fans or blowers are usually driven by special steam engines and with present methods of construction are not very efficient machines. Reckoned from the indicated horse power fans show in delivered work an efficiency varying from ten to 75 per cent, depending upon the method of construction of the fan and the condition under which it operates. The steam engine is also a wasteful machine when reckoned from the thermal value of the actual coal which is burned in the furnace. The very best engine constructed would perhaps give us a horse power for about 1.75 pounds of coal per hour and in this case the efficiency would be ten per cent. The engine which would ordinarily be used to run a blower would doubtless use nearly six pounds of coal per horse power per hour, in which case its efficiency would be three per cent.

A blower which has an efficiency of ten per cent if operated by an engine having an efficiency of three per cent would show a joint efficiency of transformation of heat into work of only 0.3 of one percent. This is no doubt the poorest case that would be tolerated in practice and we can doubtless consider as representing average conditions, an engine as having an efficiency of four per cent and a blower of $16\frac{2}{3}$ per cent, so that the joint efficiency would be $\frac{2}{3}$ of one per cent for average practice. For best practice the engine might have an efficiency of five per cent, the blower of 25 per cent, giving a joint efficiency of 1.25 per cent.

In many cases it should also be mentioned that the exhaust steam from the engine can be used for heating or for other useful purposes, in which case the efficiency of the engine could doubtless be considered as about 80 per cent or about 20 times that in which the exhaust steam is wasted.

Let r equal that percentage of heat in the coal burned under a boiler which is converted into mechanical work by an engine and shown by an indicator diagram, f that percentage of the indicated horse power of an engine which is utilized in moving air.

The total useful work performed by a fan or blower will then be

$$W_r = 778rfQ \qquad (11)$$

the efficiency of the fan and blower combined being denoted by rf.

The ratio of the useful work done by a fan to that done by heat in

a chimney when discharging air will be found by dividing equation (11) by (4)

$$R_f = \frac{W}{W_d} = \frac{778\,rfQ}{\dfrac{hQ}{cT}} = \frac{778\,cTrf}{h} = \frac{185.2\,Trf}{h} \qquad (12)$$

When rf = 0.003 = the lowest value, and outside temperature = 60°F, T = 60 + 460 = 520 in all cases

$$R_f = \frac{280}{h} \qquad (12a)$$

When rf = 0.0066, the average value

$$R_f = \frac{620}{h} \qquad (12b)$$

When rf = 1.25 per cent, the best value with a steam engine

$$R_f = \frac{1203}{h} \qquad (12c)$$

For the case when the exhaust steam may be utilized or the fan can be driven by shafting r may equal 80 per cent and f $16\frac{2}{3}$ per cent and rf = 11.3 per cent,
for which case,

$$R_f = \frac{10600}{h} \qquad (12d)$$

The following table gives the ratio of efficiency of mechanical ventilation to that of heat ventilation, air being discharged from the

TABLE SHOWING NUMBER OF TIMES THAT FAN OR BLOWER IS MORE EFFICIENT THAN A CHIMNEY IN DISCHARGING AIR FROM THE TOP. OUTSIDE TEMPERATURE 60° F.

| Combined Efficiency Fan and Engine Condition. | Exhaust Steam Wasted. | | | Exhaust Utilized |
|---|---|---|---|---|
| | 0.003 Poorest. | 0.0066 Average. | 0.0125 Best. | 11.3 Average. |
| Height Chimney, Feet. | Ratio of Efficiencies. | | | |
| 10 | 28 | 62 | 120. | 1060 |
| 20 | 14 | 31 | 60 | 530 |
| 30 | 9.3 | 20.6 | 40 | 353 |
| 40 | 7 | 15.5 | 30 | 262 |
| 50 | 5.6 | 12.4 | 24 | 212 |
| 60 | 4.7 | 10.3 | 20 | 177 |
| 70 | 4. | 8.9 | 17 | 151 |
| 80 | 3.5 | 7.75 | 15 | 133 |
| 90 | 3.1 | 6.90 | 13.3 | 113 |
| 100 | 2.8 | 6.2 | 12 | 106 |
| 125 | 2.2 | 4.95 | 9.6 | 85 |
| 150 | 1.9 | 4.15 | 8 | 71 |
| 175 | 1.6 | 3.58 | 6.85 | 61 |
| 200 | 1.4 | 3.1 | 6 | 53 |
| 250 | 1.12 | 2.5 | 4.8 | 43 |
| 300 | 0.93 | 2.07 | 4 | 35 |

chimney, temperature of outside air being 60° F. The friction is in each case neglected; this is doubtless greater under the usual conditions of fan or mechanical ventilation than when heat is employed in a chimney, but that difference cannot make any error exceeding a few per cent in the results.

The table shows that in delivering air from a chimney 100 feet in height, even when the exhaust steam is wasted, the poorest fan will do nearly three times as much ventilating and the best 12 times as much as a chimney for the condition when both are using the same amount of heat. When the exhaust steam is utilized the average fan will move more than 100 times as much air as a chimney with the consumption of the same coal.

A fan is seldom used to draw air from a passage or flue, but is often used to deliver air into a passage or flue and as this air is seldom heated the work of a fan under usual conditions is more fairly compared with the second case in chimney ventilation, viz., that of delivering cold air into a chimney.

For this case the ratio of efficiencies will be found by dividing formula (11) by formula (9)

$$R_c = \frac{W_f}{W_c} = \frac{778\,rfQ}{\dfrac{QhT}{cT'^2}} = \frac{778\,crfT'^2}{hT} = \frac{185.2\,rfT'^2}{hT} \qquad (13)$$

When the outside temperature is 60 degrees T = 520 degrees which will be used in all cases as before.

Substituting rf = 0.003 we have

$$R_c = \frac{0.001065\,T'^2}{h} \text{ (poorest fan and engine.)} \qquad (13a)$$

Substituting rf = 0.0066, we have

$$R_c = \frac{0.002343\,T'^2}{h} \text{ (average quality fan and engine.)} \qquad (13b)$$

Substituting rf = 0.001.25

$$R_c = \frac{0.00444\,T'^2}{h} \text{ (best quality fan and engine.)} \qquad (13c)$$

Substituting rf = 11.3

$$R_c = \frac{0.04015\,T'^2}{h} \text{ exhaust steam utilized.)} \qquad (13d)$$

The relative efficiency in all these last cases depends upon the absolute temperature of the chimney gases directly and of the height of the chimney inversely. For this reason the results are more complicated than the preceding and only one case, that of average value when the exhaust steam is wasted, is tabulated. The outside tem-

perature is assumed, as before, at 60 degrees F., the inside temperature is assumed as shown in the headings of the columns. The value of T′ the absolute temperature in the chimney is in every case 460 plus the temperature Fahrenheit. The following table shows the number of times that a fan is more efficient than a chimney for conditions of heights and temperatures in drawing air into the chimney.

Péclet in his treatise "Traité De La Chaleur" considers the engine and fan about three times as efficient as has been taken in the tables accompanying this article and hence deduces a set of numbers of about three times the value given here.

TABLE SHOWING NUMBER OF TIMES FAN OR BLOWER IS MORE EFFICIENT THAN A CHIMNEY IN DELIVERING AIR AT 60° F. INTO BASE OF CHIMNEY. FRICTION NEGLECTED AND FAN EFFICIENCY FIGURED FOR AVERAGE CASE, EXHAUST STEAM NOT UTILIZED.

| Temperature of Chimney Fah. | 80° | 100° | 150° | 200° | 250° | 300° | 400° | 450° |
|---|---|---|---|---|---|---|---|---|
| Height of Chimney Feet. | Ratio of Efficiencies. | | | | | | | |
| 10 | 68.4 | 73.4 | 87.3 | 102 | 118 | 135 | 173 | 194 |
| 20 | 34.2 | 36.7 | 43.6 | 51 | 5.9 | 67 | 86 | 97 |
| 30 | 22.8 | 24.5 | 29.1 | 34 | 3.9 | 45 | 57 | 65 |
| 40 | 17.1 | 18.3 | 21.8 | 24 | 29 | 34 | 44 | 48 |
| 50 | 13.7 | 14.7 | 15.4 | 20 | 24 | 27 | 35 | 39 |
| 60 | 11.4 | 12.2 | 14.5 | 17 | 19 | 22 | 28 | 32 |
| 70 | 9.8 | 10.5 | 12.8 | 15 | 17 | 19 | 25 | 28 |
| 80 | 8.5 | 9.2 | 10.9 | 12 | 15 | 17 | 22 | 24 |
| 90 | 7.6 | 8.1 | 9.7 | 11 | 13 | 15 | 17 | 21 |
| 100 | 6.8 | 7.3 | 8.7 | 10 | 12 | 13.5 | 17.3 | 19.4 |
| 125 | 5.4 | 5.9 | 7.0 | 8.1 | 9.5 | 10 | 13.9 | 15.5 |
| 150 | 4.6 | 6.1 | 5.1 | 6.7 | 8.0 | 9.0 | 11.7 | 13 |
| 175 | 3.9 | 4.2 | 5.0 | 5.8 | 6.7 | 7.7 | 9.9 | 11.1 |
| 200 | 3.4 | 3.6 | 4.4 | 5.1 | 6.0 | 6.7 | 8.6 | 9.7 |
| 250 | 2.7 | 2.9 | 3.1 | 4.1 | 4.7 | 5.4 | 6.9 | 7.8 |
| 300 | 2.3 | 2.4 | 2.9 | 3.4 | 3.9 | 4.5 | 5.7 | 6.5 |

NOTE.—The values in the foregoing are for an average efficiency of a fan when the exhaust steam is not utilized. For poorest condition of fan and engine multiply above values by .0465, for best condition of fan and blower, exhaust steam not utilized multiply by 1.9, for average condition of fan and engine exhaust steam utilized multiply by 17.1.

EFFICIENCIES OF FANS AND BLOWERS.—Many tests will be found recorded which give the efficiencies of fans and blowers very much higher than that taken in this article. For instance, in Vol. VII. of the transactions of the American Society of Mechanical Engineers, in a paper by Professor Trowbridge of Columbia College, is given a test of the Blackman fan. Mr. G. H. Babcock computed the efficiencies from the data given and found that they varied from 22 to 168 per cent of the power supplied by the steam engine. In a list of experiments of fans given in Vol II. of Mills' work on Heat the 24 to 69 per cent of the power supplied. These high and impossible efficiency of the same fan in the same test is stated as varying from results were doubtless obtained in this case by an error in measure-

ment of the air delivered. It will be found if careful experiments are made that the air delivered from a fan does not move with uniform velocity, on the contrary it varies extremely in different portions of the cross section of a pipe, and hence the greatest care must be taken to obtain average results. The instruments, especially the anemometer which is ordinarily employed to measure the velocity of air, needs to be frequently standardized and handled with the greatest of care, otherwise the results may be seriously in error. Some tests were made some years ago by Professor S. H. Woodbridge of the Massachusetts Institute of Technology on a large number of fans and blowers; the efficiency or the ratio of useful work to that supplied the fan was found to be as follows when operating under the least working pressure, 0.05 of an inch.

| TEST OF BLOWERS. | | | TEST OF FANS. | | |
|---|---|---|---|---|---|
| Symbol. | Speed. | | Symbol. | Speed. | |
| | 300 | 500 | | 500 | 700 |
| | Efficiency % | | | Efficiency % | |
| 1 | 14.9 | 13.4 | 6 | 13.7 | 16.4 |
| 2 | 4.6 | 5.7 | 7 | 13.5 | 15.3 |
| 3 | 15.6 | 15.1 | 8 | 16.4 | 19.5 |
| 4 | 15.7 | 17.3 | 9 | 11.1 | 12.9 |
| 5 | 14.8 | 14.6 | 10 | 14.4 | 15.2 |

Péclet in his treatise "Traité De La Chaleur" gives a number of tests of blowers; the efficiency of these various tests, each being of a different form of fan, are as follows: 15, 16, 18, 20, 10, 25, 17, 20, 27, and 35 per cent; the last two experiments being made with a fan having helicoidal surfaces and in every respect a portion of a screw.

In addition to the experiments above cited quite a number have been made in the laboratories of Sibley College and the results have in every case been within the limits mentioned. In general it will be found that as the pressure against which a fan works increases to a certain amount its efficiency will also increase, but when the pressure passes a certain point the efficiency will commence to diminish. This is doubtless due to the fact that the friction of the bearings makes a larger proportion of the total when the pressure is light than when it is somewhat greater, but that the greatest efficiency otherwise would be obtained at the lowest pressures.

## DISCUSSION.

Mr. Harvey:—What is your opinion in regard to the heating plant at Cornell University? Would it be more economical using

the fan, with an uptake usual size and height, instead of the present chimney, than with a natural draft for the purpose for which it is used?

Prof. Carpenter:—Taking all the heat out of the boiler, I suppose?

Mr. Harvey:—Yes, after having utilized it.

Prof. Carpenter:—Well, I suppose there is no question but what the fan would be more economical, provided it could be practically adapted to the case. I do not suppose there can be any question about its use in many cases. The statements about chimneys do not refer, you understand, to power plants, because the conditions are different. I have not considered chimney friction, but I could say that the friction in a power chimney and the losses are so large as to entirely spoil all our theoretical formulas. You will notice, as the chimney temperature reaches 450 degrees, the relative efficiency has decreased to over 15 per cent, showing that the hotter our chimney the less the efficiency is as compared with the fan.

Mr. Gormly:—Given a case where there is a flue taking air from two or three stories, with a register on each floor, where should the aspirating coil be placed in such a flue? Where would be the proper place to introduce a steam coil, at the base, or partly up in the chimney, or the corner of the chimney?

Prof. Carpenter:—The poorest thing that can be done is to distribute the heat the whole length of the chimney. The heat is much more effective if it is concentrated at one point, and put as close to the admission, should the aspirating coil be placed in such a flue, as it can possibly be. This is a difficult question to answer, but you cannot get the heat well distributed unless the air is passing over the heating surface.

Mr. Gormly:—I ask this question because I had a dispute with an architect where he required that a 4-inch steam pipe be run in the corner of a rectangular chimney flue from base to summit as an aspirating coil. I claimed that placing a steam coil in the base of the chimney would give better results. He allowed it to be placed at the base. We have had excellent results that way. But would we have as good, or better, if run his way? My argument was that the placing of the heat in the base of the flue gives greater height to the flue than the placing of heat in any other position.

Mr. Kent:—I have read this paper with a great deal of interest in the short time I had to give to it, and I think it is all right, except that it needs an appendix, which I hope Prof. Carpenter will put to it, stating the practical bearing of it all. I will give him an idea of what he might add as an appendix. I should say that, nevertheless, we must continue to use chimneys and not use fans in a great many

cases. We have here, say, a steam boiler discharging gases into the chimney at 450 degrees. We may have a flue in this chimney into which we wish to discharge air at 80 degrees from a room. Then we have a chimney used for two purposes; one to exhaust foul air at 80 degrees and the other to take the exhaust heat from the boiler at 450 degrees. According to the table on page 7, a fan would be 19 times as efficient for discharging the hot gases as this chimney at 450 degrees, and another fan used to ventilate this room, discharging the foul air at 80 degrees would be about seven times as efficient as the chimney. That is, we can either use this chimney, or substitute two fans, one of which would be 19 times and the other seven times as efficient as the chimney. Nevertheless, I say, we must keep the chimney and not use the fans, for the reason that this heat going away from the boiler is something we are throwing away, and there is no way to use it except by buying an expensive economizer. We cannot get a boiler to work with a chimney having a discharge temperature of much less than 45 degrees, and this amount of heat while it does represent 20 per cent of the whole amount of fuel put under the boiler, has necessarily to be wasted. So, when we must have the chimney to take away gas, it does not cost us anything to use it for ventilation, while the fan is an expensive apparatus, continually using steam. That is the appendix I would put to the paper.

Mr. Barron:—I should like to give a little practical illustration of Prof. Carpenter's paper. In giving the relative efficiency of the flue and fan, or the gravity and blower systems, he leaves out of his calculations the heat units given off from the bodies of the occupants of the building to be ventilated. This heat, in the case of churches and halls of audiences, if proper vent flues are provided; with slight assistance, is sufficient to ventilate the building. It is generally overlooked in comparing the fan and the flue that this heat, by increasing the volume, retards rather than aids the fans. Take Madison Square Garden, for instance, and assume that there are 10,000 men in it, at a political meeting. Assume that each man is giving off ten heat units per minute, or 600 per hour, which is only a little more than is generally accepted. Assuming that these 10,000 men are giving off 100,000 heat units per minute, and allowing 43 heat units per horse power per minute, we have got a force equal to 2,325 horse power in the heat coming from the bodies of the occupants of the building.

A Member:—That is not right.

Mr. Barron:—I have the same right to use coefficients and con-

pounds of coal (you have .15,000 heat units in a pound of pure carbon); assume 10,000 heat units in a pound of coal; I have 100 pounds of coal a minute or 6,000 pounds or three tons an hour or the equivalent of 72 tons in 24 hours, to be applied to moving the air out of the ventilating flues. It would seem to me that in a theoretical consideration of the relative efficiency of chimney and fan this part of the problem should not be overlooked. I question whether, if economy were the only consideration, it would not be more economical to ventilate a building like Madison Square Garden with chimneys having coils at their bases (in other words, the gravity system) than it would be to ventilate it with fans. Mr. Kent has introduced the question of boilers, but I do not agree with him at all, for I think, if we were real engineers, we would utilize all the heat in the boiler by the use of the economizer and blower combined. The trouble with men like Mr. Kent is that they do not say so because they cannot do it themselves, therefore they must not encourage anybody else to do it. The right thing is to let the crank and the inventor work it up, and then tabulate and profit by their work. Two men that are now dead discussed this subject years ago, Mr. Babcock and Prof. Trowbridge. Prof. Trowbridge is reported in the transactions of the Mechanical Engineers for 1882. It was, I believe, the first attempt to give data and formulæ for proportioning heating surface required at the base of ventilating flues. In 1885 he published another paper on the relative efficiency of the flue and fan. That is the time Prof. Carpenter refers to, when Mr. Babcock discussed it. Mr. Babcock showed that the test made of the disk fan proved such a high efficiency in the fan that the fan was running the engine. Afterward, I believe, Prof. Trowbridge ventilated part of Columbia College with flues with a peculiar form of coil at their bases, designed by himself. In the paper in the transactions of the Mechanical Engineeers, in 1885, Prof. Trowbridge stated: "If the chimney is 100 feet high the fan will be 38 times more efficient than the chimney, and the table shows that the velocity of flow by the fan may be quadrupled before the cost exceeds that of the chimney. If the chimney is 200 feet high, the fan will be 19 times more efficient than the chimney." In the first paper, in 1882, he said the flue was far more economical than a fan blower, and he named the make of the blower and the size of the engine and everything—nothing indefinite about it at all. I will just read that memorandum: "Compared with the estimate of the horse power required for a Sturtevant blower to produce the same effect the steam coils are more economical than the blowers. There seems to be no doubt that steam coils, properly devised

and adapted to chimneys or flues, will give more efficient ventilation than the blower for less cost of construction and maintenance." At this time Prof. Trowbridge claimed that the chimney was more efficient than the fan. I believe it is. I believe the statements made in Prof. Trowbridge's first paper are absolutely true, or nearly so, but this question has a peculiar importance to the men doing gravity work, a class of work of much importance to the heating and ventilating engineer, and deserving a great deal more respect than is generally accorded to it by those who, like myself, are associated with the steamfitting industry, and knew nothing until recently about the meritorious work done by gravity engineers. Mr. Wolfe and the men associated with him have given me an idea of the work these men have done, which really gives you a great deal of respect for them. That they often make failures, as Mr. Wolfe confesses, is due to conditions that are not their fault. I am opposed to fans. I think the fan is a very crude and inefficient apparatus and I want to put on record, with this paper now, a statement of my reasons.

It would seem to me that, if fan blowers have only an efficiency of 15 to 20 per cent, that engineers should be able to provide a more economical machine for ventilating purposes, and I think some engineers abroad have done so. Assume that an ideal machine has an efficiency of 75 per cent, and a machine, such as I am going to describe further on, has an efficiency of 50 per cent, and the fan 20 per cent, it would certainly seem that the proper machine for ventilating and heating would be the one giving the 50 per cent efficiency. The machine that I refer to as giving the 50 per cent efficiency is described on page 120 of Dr. Billings' first edition of his work on heat. He says, "In the House of Commons, during the hottest weather, a difficulty was experienced in passing a sufficient quantity of air by means of the furnaces. To remedy this defect an air machine was placed in the lower chamber to act instead of, or assist, the furnaces. The machine is double acting. The blowing chambers are rectangular in section 8 feet by 6 feet 6 inches. They are placed side by side. The pistons are supported on double piston rods, running through stuffing boxes at both ends. The machine is driven by noiseless friction gears, by a small engine of four horse power, the pumps making 16 strokes per minute, changing the air in the house six times per hour. The valves are of thin sheet India rubber, bending on wire settings." Dr. Billings is describing the methods of cooling the House of Commons in summer time. H. Bauerman, F. G. D., describes a similar machine, used in ventilating a coal mine, as follows: "The largest of

the class of piston machines is that at Nixon's navigation pit, near Aberdore, which has rectangular pistons 30 feet by 22 feet, moving horizontally through a stroke of seven feet, the lower edge being supported on rollers running on rails. An improvement in the foregoing are the rotary piston machine of Fabry and Lemelle, the former resembling Root's blower. Lemelle's machine is a vertical drum revolving eccentrically within a cylindrical casing. The drum carries three pointed blades, which are drawn in or out by radius bars as it revolves, so as to enclose and sweep out at each revolution the body of air included between the two cylinders. This is a very economical machine. Now, the correct way to have improved the paddle wheel for steamers was to substitute the screw, and the right way to have improved the overshot and undershot water wheels was to substitute the turbine, and the correct way to improve the fan blower is, I believe, to substitute a positive air moving mechanical device, such as are here described by Billings and Bauerman. I believe that the time has come to produce a special machine for hot blast heating, a positive machine on the air pump principle, as described by Professor Ewing, in his article on ventilation in the Encyclopedia Britannica. Such machines are the next advance in air moving for ventilation, and I think the great value of this paper of Prof. Carpenter's is that it shows clearly what a poor device the fan blower is. What we want is comparative tests between Baker, Root, McKensee and other positive blowers, and data of tests of air pumps in comparison with fan blowers, and comparative tests with disk fans and fan blowers, and when we have these we will see this blower humbug in the same light that we now see the direct steam pump humbug since Dr. Chas. E. Emery made his investigation into the amount of steam per horse power of direct acting pumps. I have to admit that the blower, like the direct acting steam pump, is a first-class transitional device, but no amount of testing could show honest economy in a direct steam pump, and the same is true of a fan pumping air. I venture to say that we have now more data on fan performance than we want, and that most of it will never be of much practical use, and that if we could employ all the experts in the country for the next year testing fans the knowledge so acquired would not be worth five cents to any man practically engaged in making or erecting fans. No man to-day wants tests made of paddle wheels and I rather think the air paddle or fan does not deserve any better treatment. My own opinion is that all peculiar shapes of blades for fans and peculiar forms of hubs and wheels and outlets and casings are meretricious, and are like the attempt made 30 years ago to improve the paddle wheels of steamboats by having feathering

paddles, when the real way was to substitute the screw. Many tests were made and much work was done on patent paddle wheels, but it was all wasted effort. I am inclined to think that our time discussing fans is of the same character; a fan is only an air paddle and a crude and cheap device for air moving, and some positive device such as an air pump or positive blower is the proper substitute. All the improvements made in fans since Dr. Reed's book was published, nearly 50 years ago, are not worth talking about.

Prof. Carpenter:—The discussion is considering different kinds of fans and different kinds of blowers and different ways of sending air through the chimney. I purposely left all those things out of the paper, because I did not think they had any place in a general discussion, although important. It seems to me that whether the efficiency is ten per cent, or five per cent, or 50 per cent, or 500 per cent does not have very much to do with the results presented in the paper. The object of the paper was merely to lay before you the facts as they seem to exist in regard to the means of moving air, and not to say anything about the different methods, because I think, if we go into details, that we will be gray headed before we get through, because there are something like five or six hundred different ways of moving air. I believe there are some people who believe in a method of moving air by impulse, i. e., by forcing a jet of air under high pressure into the chimney, and there are a good many other ways not considered in either paper or discussion.

Mr. Wolfe:—If I digress a little from the line of the paper, it is to ask for a matter of information. In computing the value of a ventilating chimney, are the corners of any value? I mean the ventilating corners. Shall we figure the radius of the circle that we can make or shall we figure the square of the chimney? Are the corners of use?

Mr. Harvey:—What part of the corner would you leave off, Mr. Wolfe? (Laughter.)

Mr. Wolfe:—What I mean is, is not a round chimney more efficient than a square one?

Mr. Harvey:—If there is an openng in the corner I should consider that just as good as any other part of it.

Mr. Wolfe:—Haven't you seen in a ventilating shaft two down currents in the corner?

Mr. Harvey:—When they were not equally heated. It is naturally supposed that the air would be equally distributed in going up.

Mr. Wolfe:—It is a question of figuring and science. I only ask for information.

Mr. Harvey:—I have seen chimneys frequently increase their capacity by adding the fan blast.

Mr. Blackmore:—There are one or two things I want to say in regard to this matter. This is a discussion as to the relative merits of the fan and the gravity system. It is pretty generally known that the fan system is much more efficient than any other, but for other reasons the gravity system will always be with us. There is a very strong objection, especially in the rural districts, to having anything in the shape of machinery in a building, and the gravity system has to be resorted to as the only one. Now, the reason for the difference in the efficiency of the two was very fully explained by Prof. Carpenter in the height of the chimney. If we could get a chimney high enough we could make the chimney more economical. The question was brought up yesterday, when Mr. Wolfe spoke of the very easy matter of ventilating a building with a difference of 40 degrees between the inside and outside of the building, and I made the remark that it would be ventilated even if there was an equilibrium, provided there was heat in the chimney. But in providing this heat we spend, as Prof. Carpenter states here, probably six times more than if we had a properly applied fan. We cannot do without the gravity system, and we have to recognize the fact that it is with us to stay and we want to study it the same as we study the fan, or, as Mr. Barron says, the blower. It has been a very difficult thing for the lay mind to understand why the gravity system should be more expensive, as it cannot see the power expended, but the reason is explained in this paper; the chimney being short, the heat escapes before we have actually used the power that is in it.

Mr. Wolfe:—Prof. Carpenter this morning admits that we can do all that heating that we can do with a fan, and his findings are undoubtedly true. But he can do it ten or fifteen times cheaper with a fan than we can with the direct power of heat. I understand that in a heated flue we can move air, if we burn fuel enough to move it, but we can move it cheaper in another way. The gravity system is the system in which no other power is applied except a difference in temperature, as I understand it.

Mr. Blackmore:—Mr. Wolfe made the statement yesterday in buildings he was referring to, when there was a difference in temperature of 40 degrees between the inside and the outside, the building was very well ventilated; and when it got to be nearly in equilibrium he made the statement that it was just rotten.

Mr. Wolfe:—Not at all.

Mr. Blackmore:—What I wanted to state was that it was rotten because it was not properly attended to.

Mr. Wolfe:—I said it was simply rotten because of the lack of power to move the air.

Mr. Barron:—This is the most important subject we have here. It is the one subject we want to discuss, and I would ask you to allow a little latitude on the subject. What I should like to bring in is the proportion of heating and ventilating surface at base of flues where steam heat is used. I should like to read what Dr. Billings says. It is not exactly on the subject, but it bears very close to it. This is really a part of Prof. Trowbridge's paper—this whole thing. Before reading what Dr. Billings says, I will read the rule that John J. Hogan gave: "An approximate way of proportioning this heating surface is to divide the surface of the side of the flue in square feet by 12; the result will be the square feet of heating surface." That is an empirical rule, but it gives far less surface than Dr. Billings' and for that reason I approve of it. Dr. Billings says: "Suppose the air of a room 30 by 40 and 15 feet from floor to ceiling is to be removed four times every hour; the cubic contents are $30 \times 40 \times 15 = 18{,}000$ cubic feet. If the flue is 50 feet high, we shall have:

$$S = \frac{1500 \times 4.9}{50} = 30 \times 4.9 = 147 \text{ square feet.}$$

Hence the conditions of ventilation assumed will require an aggregate area of ventilating flue of 4.8 square feet in cross section and 147 square feet of heating surface in the coil or cluster of pipes at the base (about four times too much). If more than one flue is employed, which would probably be desirable, in order to have a better distribution of the inflowing air (two flues, for instance), then each would have an area of 2.2 square feet, and each would be heated at the base by pipes having $73\frac{1}{2}$ square feet of surface. All these rules give a ridiculously large coil, unnecessarily large for what is required.

Prof. Carpenter:—The paper was intended merely to present that fact and I think that it has been pretty well discussed. The fact that fan ventilation could never replace gravity ventilation for certain cases is certainly well known and is very evident. Gravity ventilation must be used in many cases, although it may cost a thousand times more; it is seldom possible, of course, to introduce mechanical ventilation in connection with domestic heating and in a thousand other instances that might be mentioned. In connection with the chimney, I wish to call the attention of the society to the fact that Mr. Kent has been at work on a scientific instrument for measuring draft that is of interest, since the measurements of low pressures in moving air columns is difficult, and I hope Mr. Kent will show the

society just how it operates. It is an improved "draft gauge" for chimneys.

Mr. Kent:—This (exhibiting a gauge) is the ordinary U-tube draft gauge, which you all know. We partly fill it with water and put a scale reading to tenths of an inch behind it, attach one leg to the chimney and read in tenths of an inch the amount of draft. The objection to that form of draft gauge is that when we want to do any fine work, to measure any slight difference due to difference of coal, difference of firing, etc., it is difficult to have it fine enough. We have to read only a quarter of an inch altogether, and in reading that quarter of an inch, we have to read the bottom of the meniscus, as it is called, of the two columns of water; and to read it against the scale, sometimes by an imperfect light, we are liable to a good deal of error, amounting to perhaps three or four hundredths of an inch. It has long been desired to find a way of multiplying that movement. There have been several different ways proposed and some adopted by different engineers. What I have to show is simply another way to multiply the movement of the draft gauge, so as to be able to read it easily. This (showing the instrument) is an ordinary tomato can (A in the sketch), with a ring soldered in the top of it and two clips of tin on the side holding a scale made of celluloid with graduations of 32nds of an inch. For fine readings we could use a vernier, so that readings could be made to hundredths of an inch or less. This can is inverted in a tin can B, a little larger than the first in diameter and of the same height. Inside of it is a ¼-inch bent tube C, soldered to the bottom, and extending through the side, in which it is soldered water tight. The top of this tube is level with the top of the outer can, so that when we nearly fill the can with water there will be no leakage through the tube. The inner can is carried by a long spring, which was taken from an old Hartshorn shade roller, which is about the right kind of spring for the purpose. That is hung on a support which is car-

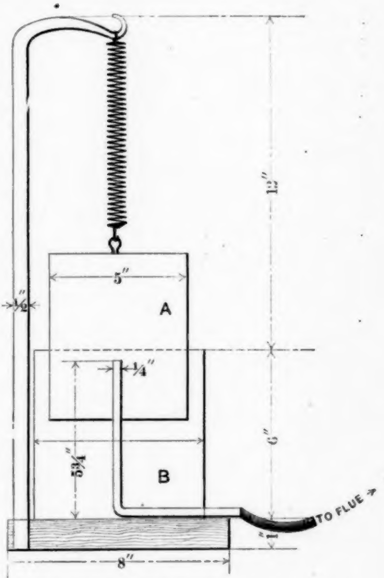


Fig. 42.—KENT DRAFT GAUGE.

ried on the wooden base on which the outer can rests. The outer can being nearly filled with water, the height of the spring support is so adjusted that the edge of the inverted can just dips under the water, the outer end of the tube being open to the atmosphere. The inner can then contains air at atmospheric pressure. Now we attach a rubber tube at the extremity of the tube projecting from the bottom of the can. If we now apply suction to the end of the rubber tube it will draw air from the inverted can and extend the spring until its resistance just balances the difference between the pressure of the atmosphere acting on top of the inverted can and that of the partially exhausted atmosphere inside of it. By applying a suction equal to that of a chimney draft, which shows $\frac{3}{4}$ of an inch on an ordinary U-tube gauge the can descends about four inches. The actual multiplication of the reading by this particular instrument is about $4\frac{1}{2}$ to 1, with the additional advantage that in reading this celluloid scale against the black edge of the outer can we can read it easily to 32nds of an inch, and can split the 32nds of an inch in half by the eye, and, besides, we do not have the error of reading the meniscus of the water, as in the U-tube gauge. The motion is $4\frac{1}{2}$ times as great and the precision of reading is much greater. When we put on a vernier we can read still finer. If we wish to increase the sensitiveness we can take a weaker or a longer spring than this one, or we can increase the diameter of the inverted can. If we double the diameter and make four times the area, it will be four times as sensitive; so we can have it read down to thousandths or ten-thousandths of an inch of water column if we wish. While this looks like a very delicate sort of apparatus, it is remarkable how stable it is, coming absolutely to rest when the suction is constant, as may be seen when we pinch tight the rubber tube after applying suction.

Mr. Blackmore:—I should like to ask Mr. Kent how, by making the diameter larger, you would increase the sensitiveness of it. I do not quite understand that.

Mr. Kent:—The weight of water, 62.4 pounds per cubic foot, is one of the factors used in making the calculations. In standardizing the instrument it can be done in two ways; first, by applying suction and shutting the tube off and getting what the multiplication is by comparing it with the measurement of the same partial vacuum by a U-tube. It can also be made in a direct way, by adding weights on top of the inverted can and determining what weight is required to extend the spring 1, 2, or 4 inches, and then making a calculation using these weights, the weight of an inch of water column and the area of the inverted can as data. By comparing both methods of

calibration, I have found that the rating is perfectly constant for each fraction of an inch of extension of the spring.

Mr. Blackmore:—You now have the diameter multiplied about four times?

Mr. Kent:—$4\frac{1}{2}$ to 1.

Mr. Blackmore:—Now, where is the relation? Is the relation between that and the U-tube——

Mr. Kent:—Not at all. In an ordinary U-tube it makes no difference what size the tube is. All we measure is simply the difference in level of the columns of water. That difference in level is the excess of the pressure of the external atmosphere above that inside of the chimney. That little difference of water level is the exact equivalent of a certain difference of pressure per square inch, which may be measured either in fractions of a pound or of an ounce, or in height of a column of mercury or of water.

Mr. Blackmore:—Assume that was five inches.

Mr. Kent:—It would be the ratio of the square of the diameters. If I apply suction here I have an atmosphere in this can of less pressure than the atmosphere outdoors, and the amount of the total pressure is registered exactly by the extension of the spring, but that total pressure is a pressure per square inch multiplied by the number of square inches of area of the inverted can; so if I double the square inches of area in the can I will have twice the pressure and my spring will extend twice as far.

Mr. B. Harold Carpenter:—The spring is the test and not the water, in this case.

Mr. Kent:—The spring is the test.

Mr. Blackmore:—You would have to have a different table with every spring?

Mr. Kent:—Yes, a different table with every spring.

Mr. Cary:—There is one point of error in very light readings. It does not amount to very much. But nearly every spring, if perfectly wound, is wound so that the coils crowd one another. You have to open the spring sufficiently to have a little space in between each coil, and starting from that point the elongation for each fraction of an inch is the same. Mr. Kent has spoken of it and I think it would be a good plan, if possible, to put a little vertical rod, so as to separate the spring entirely, or, in other words, start with a little load in the spring, enough to overcome that drawing together tendency, and then you can take your readings from that point without error.

Mr. Kent:—If I was improving this, the first improvement I would make would be to extend this standard; but it only requires a very little extension; a few inches brings it to the point at which it is entirely free.

# XXX.

# CIRCULATION OF STEAM FOR HEATING PURPOSES AT OR BELOW THE PRESSURE OF THE ATMOSPHERE.

BY REGINALD PELHAM BOLTON, C.E.

(Non-Member of the Society. Presented by request.)

The merits of steam heating, especially by means of exhaust steam, in comparison with other systems, are too widely appreciated to need dissection before an audience of experts.

The limitations, uncertainty, and difficulties encountered in the process are matters of more cogent interest. In this connection some description of apparatus capable of meeting the conditions cannot fail to be of interest. Prior to the description of any improved apparatus it will advantageous to enter somewhat into the difficulties and limitation referred to and to extend the study to some of the claims commonly made for the maintenance of unimproved apparatus.

The natural circulation of steam in any system of piping is governed by natural laws of inertia, friction, and, to some extent, of capillary attraction. Steam entering any pipe traverses the tubular space like other bodies at a rate dependent upon its superiority of pressure over the resistance encountered. It is subject during its progress, however, to a diminution of its volume, due to condensation.

The products of this condensation, being of a heavier nature than the elastic vapor, will continue their motion only to the degree to which speed is imparted to them by the travel of the steam. If perfectly free of all frictional contact, their speed would be a natural acceleration, but owing to their adhesion to the skin of the tube the effect of retardation is very marked.

At this point it may be instructive to point out that the common theory of the flow of condensed water in pipes is largely in error. It is usually assumed to be drifted along at the bottom of the pipe, while a visual study of the actual effect in a glass tube will show that it is propelled all round the interior surface, the effect of gravity being sensibly smaller than that due to capillary adhesion. The usual method of dripping pipes, especially large pipes, from their lowest

level is, therefore, only partially correct; and a method more true to the conditions would be found in some arrangement of enlarging the pipe at each point of drainage, enabling water all around the interior circumference to find an exit from the drift of the steam.

Assuming the best possible condition of removal of condensation it remains a scientific fact that the less resistance opposing the flow of the moisture the easier will be its passage and the less the reduction of speed of the flowing stream. Common practice deals with initial pressures from 15 pounds downwards and with resisting pressures of from atmospheric pressure upwards. It is now demonstrable that by a system of partial vacuum it is economically possible to relieve the steam of resistance to a still greater extent. A study of the figures of the flow of liquids in standard pipes will demonstrate that the advantage in ease of flow of steam is on the side of a low pressure system into a partial vacuum as against one pressure of steam into another.

It becomes evident, from any but a very superficial examination of the subject, that the best method of considering the action of radiating steam heating apparatus is to look upon it as a condenser. It may be made, with this intention in view, a most efficient adjunct to that cycle of operations which is performed in the evaporating, usage, condensation, and return of steam to the boiler for re-evaporation. The modern method of comparison by heat units is especially applicable and is the clearest method of expression for results. This cycle is admirably illustrated in modern marine practice, where the presence of an ample cooling surface in the form of water, enables a very thorough and instantaneous condensation to be accomplished, and equally economical results could be obtained by air radiation or cooling if the conditions were approximated to marine practice. It is to be noted that the primary necessity in any such cycle of evaporation and condensation is the removal of air-gases from the condenser and also the removal of condensed water by continuous and automatic apparatus.

In a marine engine this is desirably accomplished by a separate air pump and feed pump, independently operated or attached to the main engines.

In the heating of buildings, where the heating may have to be accomplished independently of the operation of the motive machinery, the independent forms of air and feed pumps are the only suitable forms.

Where the object to be attained is the abstraction of heat from a gas the more free and expanded the volume is, with corresponding freedom of renewal of the heating element, the better the result. A

cramped and confined volume containing heat, even at a higher temperature, does not part with heat as readily as the same amount comparatively expanded and allowed to continually impinge fresh quantities as heat is removed.

In effect, the marine engineer would suffer a disappointment should he attempt to raise the exhausting pressure of the low pressure cylinder of his engine with a view to raising the temperature of the discharge water from his condenser.

The common forms of radiators, with their many points of merit and demerit as regards circulation of the heated air over their surfaces, may all be regarded from the point of view of enlargements of the pipe system. Common practice in any steam pipe enlargement would demand an efficient and automatic drainage or drip of the lower water-filled portion by some form of trap. The enlarged portion would further present an air pocket which it would be the effort of the engineer to relieve. It would not suffice to do one and leave the other undone. To relieve the air-gases only would leave the drainage at the mercy of circumstances, but if the water drip were to be sufficiently efficient and to extend freely into a lower drainage system the air-gases, after once being preliminarily removed, would automatically be drawn off with the drainage. Air is heavier than saturated steam in the proportion of 1 to $\frac{5}{8}$ at atmospheric pressure. It is a mechanical operation which drives the excluded air into the upper portions or extreme ends of radiators and coils. It therefore follows that steam, being once fully admitted to the contents of an enlargement, the air or gases, afterwards liberated by condensation, are best drawn off at the point of drainage.

On the other hand, any open system of drainage controlled at will by the operation of hand valves must necessarily be liable to derangement of operation by the least negligence of attendants. If the outlet valve, for instance, is at the disposition of the tenant of a room, it is unlikely to be at any time set so as to dispose of the products of condensation at the proper rate.

Having thus examined the conditions surrounding the removal of air-gases, we may consider their effect upon the efficiency of the heating system.

The common assumption that steam at a pressure does more radiating work than that at atmospheric pressure is based on the bare theory of difference in temperatures.

Comparing these, we find that while the latter is at 212 degrees, a 5-pound back pressure only adds 15 degrees, or about seven per cent to the heat supply, and a 10-pound back pressure adds only 28 degrees, or about 1.4 per cent per pound of pressure.

As the parting with this heat is effected by condensation and is in direct degree due to that condensation the ratio of loss of temperature, or, in other words, the gain in radiating power must be shown to be greater than 1.4 per cent per pound of back pressure, in order to exhibit any economic advantage over atmospheric circulation. As a matter of fact this is not the case with the ordinary radiator, which does not so effectively circulate the outer air over its surfaces as to enable such an advantage to be gained.

The effectiveness of any surface depends, in a much greater degree than the percentages above named, upon the removal of air-gases from the interior radiating surface and is to that extent less dependent upon the temperature of the radiator.

The presence of air-gases in the feed water and in the boiler is, in reality, a factor affecting a much larger percentage of economy, yet is one of which little notice is commonly taken. All fresh water is more or less ærated, a condition which causes losses in heat in the boiler greatly out of proportion to its amount. Given a system, therefore, which, after a short period of operation, practically excludes the air-gases from the water fed to the boiler, and it may be expected to show a steam freer of air and gases and to present a better result in radiation to just that extent. It will do more. Much of the waste heat of combustion in boilers is due to the energy wastefully expended in heating up the air and gases contained in the water, and any direct saving of fuel in that direction can thus be credited to a system of removal of air-gases from the feed. To proceed further on this question of pressures, it has been argued by those who still maintain value in pressures for steam heating systems, and who are unwilling to recognize any value in their reduction, that a back pressure upon the piston of an engine is of little moment and is practically to be counterbalanced by an equal increase of initial pressure. Such an argument, while it may successfully be utilized to recommend the adoption of exhaust steam under back pressure, as against live steam supply, cannot be extended as has been done in the following remarkable dictum, recently published: "A loss of efficiency to the engine there certainly is, but it is so small that it can be offset by an extra pound of pressure at the boiler, without cost." This question of the relative value of extra initial pressure on an engine cylinder, as against the use of a back pressure of equal extent, is one upon which has existed and still exists a great deal of misapprehension. This is scarcely to be wondered at when leading heating authorities have so deliberately put themselves on record in the wrong direction, such as the following extract from another printed statement, demonstrates:

"It is of importance to have the cylinder proportions of the electric light engines such that the desired power is developed with the back pressure as high as five pounds to the square inch; for, in American practice, such pressure may be required for heating in the coldest weather. This back pressure, if originally figured on, is neither detrimental nor uneconomical."

It is amazing how such statements can have been formulated, if accompanied by any reflection upon the conditions in a steam cylinder.

The addition of a resisting load of a given back pressure requires a full equivalent, free of all losses, not to the initial pressure, but to the average or mean effective pressure on the pushing side. In an engine supplied with steam at 80 pounds pressure, where at one-quarter cut-off the mean effective pressure is about 40 pounds, a back pressure of ten pounds per square inch is equivalent to one-fourth of the total force of the engine, and the initial boiler pressure required to make up for it would amount, not to ten pounds but to 15 pounds per square inch.

Stated in terms of powers, the results in a 20-inch engine at 200 revolutions per minute, 80 pounds initial pressure, cutting off at one-quarter stroke, would be as follows: The engine would normally indicate 250 horse power, with exhaust at atmospheric pressure. A 10-pound back pressure would reduce the power of the engine to 188 horse power, and we thus get a measure of the extra cost of putting such a pressure on the steam heating supply, it being no less than 62 horse power. In such an engine this would mean about 35 pounds weight of steam per horse power hour, and a probable fuel consumption of one pound of coal to eight pounds of steam, or $62 \times 35 \div 8 = 271$ pounds of coal per hour. More than this. A back pressure is a constant effort during the course of the stroke, whereas the steam distribution is a varying quantity. All diagrams should also be considered in relation to the movement of the crank during the same period. The initial pressure is exerted direct onto the crank pin and produces little rotating effect. Such as it is, it is met by the opposition of the back pressure. After the cut-off takes place the speed of piston increases and for a time the effectiveness of the resistance of back pressure falls, but as the end of stroke is reached the steam pressure falls until the back pressure equals in effectiveness the efforts of the steam. Here the exhaust closes and the action of compression commences until the fresh steam is admitted into the saturated mixture.

In view of such well-known conditions it shows a surprising amount of ignorance in an engineer who continues deliberately to

maintain not only the innocuous, but the economical character of a back pressure.

To obtain the net result of 40 pounds mean effective pressure in this engine as above described the horse power on the pressure side must be raised to 313.3 horse power by extended cut-off or by initial pressure.

From this 250 horse power engine the total volume of exhaust steam at atmospheric pressure would be $250 \times 35 = 8750$ pounds per hour, giving a total in heat units of $10105250 \div 250 = 40420$ square feet of radiating surface theoretically.

The same engine would, under the back pressure system, be using $313 \times 35 = 10955$ pounds of steam per hour and must therefore show an advantage in its operation in the above radiating surface of not less than 20 per cent to be on equal terms with circulation at atmospheric pressure.

In actual money cost of fuel at $3 per ton it must be superior in the same surface to the extent of 40 cents an hour or $4 per 10-hour day.

The above figures can be proportionately paralleled in any size, type, and form of engine considered, while in the case of direct acting pumps, the detrimental effect is largely increased, so that the exposition of these facts should be all that is required to put a final disposition to this ignorant view of the subject.

We arrive by this study of the internal conditions of steam circulation and heating at a set of requirements, for the fulfilment of which it has been the author's aim to find apparatus with the necessary facilities.

## PRIMARY REQUIREMENTS FOR EFFECTIVE STEAM HEATING SYSTEMS.

1. Absence of back pressure on motive engines where exhaust steam can be utilized.
2. Efficiency of drainage of supply pipe system preliminary to drainage of the radiating surface.
3. Continuous automatic drainage of condensation.
4. Effectiveness of circulation.
5. Control, or variability at will, of circulation.
6. Removal of air and gases from heat surfaces and from feed water.
7. Regulation of temperature in any part of heating surface.
8. Return of water from some moderate distance below the line of drip or drainage, if necessary.

It is unnecessary to state that there are claimants for success in dealing with one or other of these conditions, but that apparatus

which does not demonstrate its capability of compliance with all, seeing that all of them are natural features to be encountered in any heat system and are due to natural causes, must by the heating engineer be considered incomplete.

The requirements of the above, it will be noticed, are not fulfilled by any system employing one pipe for supply and return, nor by any system removing only the air-gases and not dealing with equal certainty with the water of condensation, nor by any arrangements establishing a partial suction in a coil or radiator in such a way as to act in opposition to the free drainage of the condensation, nor by any apparatus requiring more than one hand-valve for regulation by unskilled persons of a coil or radiator, nor by any system incapable of lifting the drainage from a point somewhat lower than that of outlet or of final disposition.

On the other hand, the whole of these have been found in the author's practice to be complied with by an apparatus known as the Webster combination system. This apparatus is of so interesting a character, that, it having been hitherto undescribed before a technical society, the author has prepared the accompanying illustrations, accompanying the following description. It comprises primarily an automatic outlet valve to each part requiring drainage, a connection of it to a suction apparatus, such as a pump or an ejector, the abstraction of all air and gases from the heating system, and the return of the condensed water into a heater wherein the water and gases freely dissociate in a chamber sealed from the atmosphere, and where the temperature of the condensed water, plus that of any additional fresh supply found to be necessary, is raised by direct contact with a proportional amount of exhaust or waste steam, and finally the return of the whole automatically to the boiler.

The operation of this apparatus can be brought to any degree of automatic regulation, its control is entirely in the engineer's or fireman's discretion, while leaving the control of each individual radiator or coil absolutely in the hands of the tenant or occupant, by means of one hand valve only.

A remarkable result due to this arrangement is the ability to reduce the total temperature of any separate coil or radiator by reducing the amount of steam admitted to it, without water logging or hammering, a result unknown with any other combination of steam heating apparatus.

This is done at will by closing down on the inlet supply to the desired degree. The result is the admission of a smaller amount of steam to the coil than it is calculated to condense normally. The condensation is as rapidly removed as it is formed by the opening of the

thermostatic valve and the result is the maintenance of a moderated temperature in the coil down to a temperature just above that of the surrounding air, precisely in proportion to the heat units liberated from the quantity of steam admitted. In this is to be found that much-sought desideratum of steam heating engineers, the moderation of heating to suit mild weather.

The diagrams presented herewith illustrate several methods of application of the Webster apparatus, demonstrating its flexibility to various conditions.

The preferred arrangement consists primarily of a thermostatic valve, which is shown in enlarged section in Fig. 43, and samples of which are laid upon the table. This valve contains a stalk or stem of hard rubber compound which expands under increasing temperatures. The seat, which is the outlet, is at the top and is arranged for ready adjustment by a screw driver. It is capable of being set so

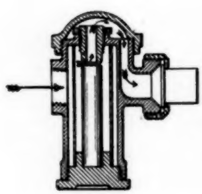


FIG. 43.

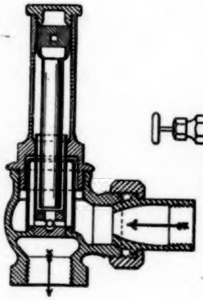


FIG. 44.

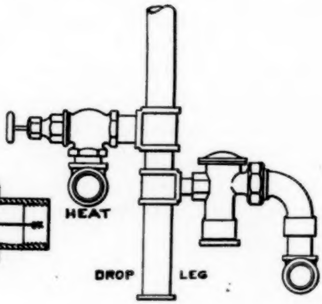



FIG. 45.

that it will open at any degree of temperature less than that of steam at atmospheric pressure.

In operation it then stands closed while steam is in the coil and in contact with the stalk, but as soon as condensation collects around it, it shortens and opens the aperture to the return pipes, in which a suction or partial vacuum exists. Another form is shown enlarged in Fig. 44, designed for application to the body of a standard screw-down valve.

The thermostatic valve should be placed at the point of drainage of the coil or radiator, as shown in Fig. 46. One of the standard sizes adopted is capable of draining 200 square feet of surface in active condensation. It will be evident that this little temperature trap, for such it is in effect, can be equally well applied to the foot of riser pipes, as shown in Fig. 45, to the ends of horizontal lines, to changes in size of pipes, and in fact to any desired dripping point.

Heavy condensation of any part can be cared for by multiplying the number of thermostatic valves at that point.

Care should be exercised that the valve is so placed that dirt and scale in the pipes do not fall into it direct and choke its inlet. This may be provided for by the drop-leg shown in Figs. 45 and 46. Its form is, however, such as will allow for a certain amount of sediment to deposit around the stalk, which is covered by a perforated screen of simple character. In Fig. 46 is shown a return-line by which the condensed water is lifted by the action of the suction.

In the basement, engine room, or boiler room, is placed the return pump, as shown in Fig. 47, which may be a direct-acting "wet-vacuum" pump, and is regulated to maintain a constant amount of suction.

The return pipes being united and brought to this pump, it is set to receive the condensation and to exert an extra suction of from one to 15 inches of mercury, according to requirements. A pump for a radiating surface of 20,000 square feet has a steam end six inches in

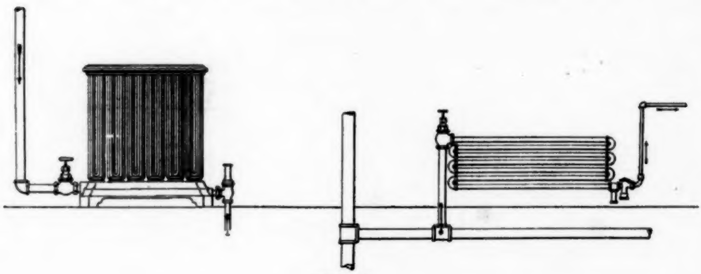


FIG. 46.

diameter and will make about 100 feet piston speed per minute. Its exhaust is taken into the heating main, and it is thus operated merely as a reducing-valve, or it may be taken direct to the feed water heater and there condensed.

The delivery of the hot returns can be effected in more than one manner. The best system has been found to be to deliver the whole into a separate "hot-well" or returns receiver, from which free egress for the air and vapors can be afforded to the atmosphere and time allowed for the operation to effect itself thoroughly. Such a receiver is shown in Fig. 47, and it may advantageously be provided with a ball-cock and float whereby any necessary auxiliary cold water supply may be automatically introduced into the returns. From this receiver the returns gravitate to the feed water heater, as desired, controlled by the automatic valve upon the latter.

The returns may, however, be delivered direct to the feed water

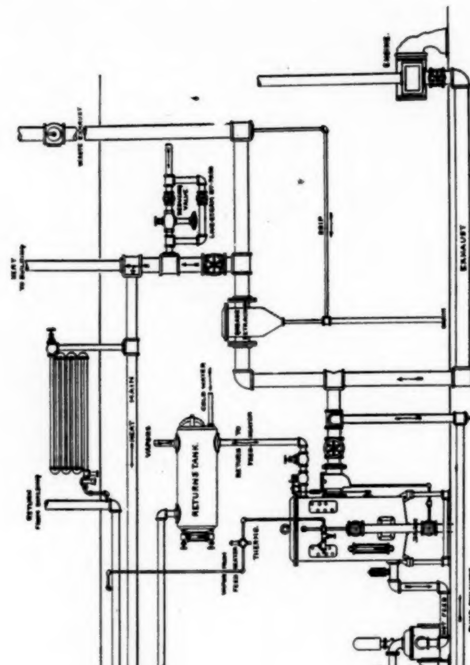

ENGINE
EXHAUST
DRIP
HEAT MAIN
RETURN MAIN
RETURNS TANK
FEED PUMP
STEAM TO PUMP
GAUGES

FIG. 47.

heater, as shown in Fig. 48, the vapors passing off to the atmosphere by a vertical pipe on the connecting pipe. The cold water supply can be controlled in this case by hand if desired.

From the feed water heater the feed pump draws its supply under a slight head automatically, its operation being controlled by the automatic valve C, which is connected to its steam supply.

A third arrangement is shown in Fig. 49, which is applicable to the use of a closed feed water heater, where such is rendered necessary

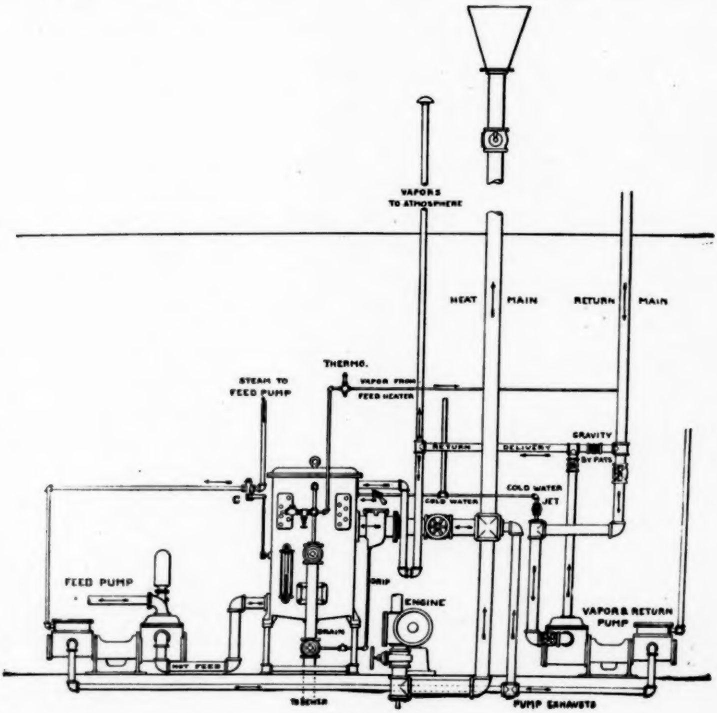



FIG. 48.

by prejudice, by the use of animal, vegetable, or impure oils, or is already installed and cannot be replaced by a sealed heater.

Here the returns can be delivered into the receiver as with the sealed heater in Fig. 47, but the feed pump must receive direct from this receiver which must also contain the additional cold water supply, and the delivery of the feed will then take place through the closed heater.

The Webster feed water heater plays so important a part in the combination that it must now be described:

It is not to be classed precisely under the type of "open" feed water heaters, except in so far as that a portion of the exhaust steam is brought directly in contact with and is condensed by the feed water proper. It is a closed or sealed chamber, rectangular in form, provided with an upper inlet for the feed supply, which may be hot returns or cold water or both, and an inlet for steam provided with an

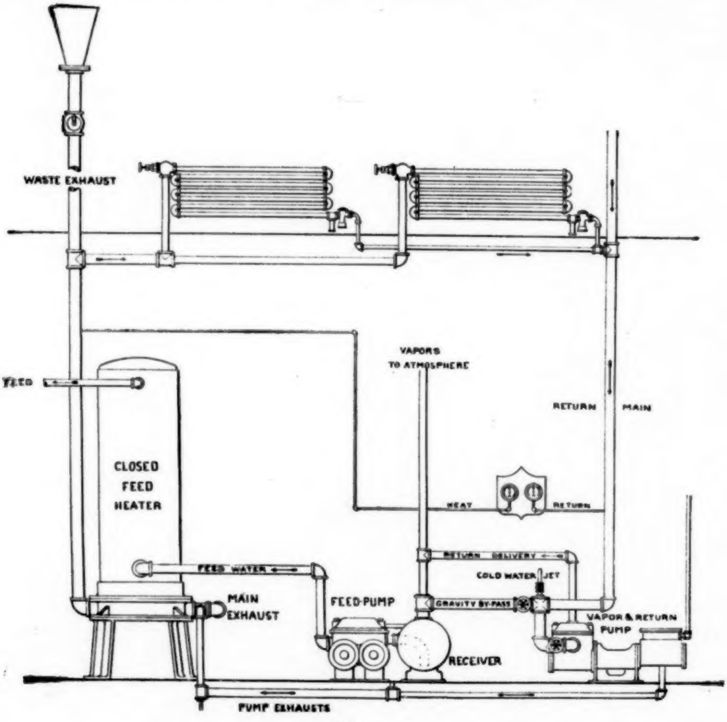


FIG. 49.

independent oil separator or grease extractor, operating upon the steam previous to its entry to the interior. Upon entering the steam encounters a set of oppositely inclined and perforated trays of copper sheet, over which the feed water from above is spread and percolates in a very finely divided condition, inviting most effectively the absorption of heat from the ascending steam particles. Any vapor or gases that escape the condensation of this process encounter above the upper tray a coil of parallel brass pipes through which the enter-

ing feed water passes on its way to the trays. The effect is thoroughly to condense such gases or vapors and leave them in a condition ready for removal by the air pipe provided, which may be treated, as shown, by connection through a thermostatic valve into the vacuum return system, or may vent to the atmosphere. The body of heated water, accumulating in the lower portion of the heater, affords a desirable opportunity for the settlement of solids, to be drawn off by the inclined bottom and drain pipe below, which is also provided with an extension to the water surface to draw off floating scum or impurities of light specific gravity. The outlet to the feed water heater is provided under a plate hood extending down into the body of water and excluding the surface impurities. Upon the normal water surface is arranged a copper float box, operating, through the only exterior gland, a lever, which may be arranged as shown to control the water supply, or if desired to control the steam supply to the feed pump.

The feed water heater having thus raised the temperature of returns and cold feed, the released air can be very completely removed, as described, previous to its transference to the boiler, by the connection of the top of the feed water heater into the return system.

One further and very remarkable feature of this system must be noted. It is quite practicable to operate the returns from radiators situated below the floor of the engine-room, or below the level of the return pump, or to lift the drainage of any given portion to quite a considerable extent, as shown in Fig. 46. The partial vacuum maintained and which extends from the return system will handle a much greater height of return than its theoretical value in inches of water. A radiator has recently been added to the Syndicate Building in this city, in which the returns are lifted seven feet without any addition to the suction previously maintained, and which varies from four to 15 inches. This has been found to be the case even when condensed water has been allowed to collect in the radiator over night.

The effect is doubtless due to the sweeping action of the removal of vapors with the condensation in the same pipe.

No other means exists of handling this problem, and its practicability is a great convenience in city buildings.

One of the features permissible with the use of a Webster return system is the installation of return pipes of less size throughout than with a gravity return.

Experiment has shown that a thermostatic valve, having connections of an area of .1 of a square inch or equivalent to a standard pipe of ¼ inch diameter, will convey the condensation and vapor from 160 square feet of radiating surface, which may be safely put, in

practice, at 100 square feet. So small a pipe is, it is true, inadvisable in steam practice merely on account of its liability to damage, and it has therefore been usual to connect the thermostatic valve by ½ inch pipe. This size may, in exposed or long horizontal lines be still further increased to ¾ inch diameter, but additions thereto as other return connections are brought into it, need only be made in the original proportion of .1 of a square inch to 100 square feet of surface. The accompanying comparative diagram of returns on both systems will show that quite a considerable economy is to be effected in this way over a two-pipe gravity system, and of course no air pipe lines are needed at all.

In a large building such as a modern office building, in which the riser lines are very extensive, the economy is quite considerable.

COMPARATIVE PROPORTIONS OF RETURN PIPES IN VACUUM AND GRAVITY SYSTEMS.

| Vacuum Return. | Heat. | Gravity Return. |
|---|---|---|
| | 100 sq. ft. — 100 sq. ft. | |
| ½" | 1"-¼ | 1" |
| | 100 — 100 | |
| ½" | 1"-½ | 1"-¼ |
| | 100 — 100 | |
| ½" | 2" | 1"-½ |
| | 100 — 100 | |
| ¾" | 2" | 1"-½ |
| | 100 — 100 | |
| ¾" | 2"-½ | 2" |
| | 100 — 100 | |
| 1" | 2"-½ | 2" |
| | 100 — 100 | |
| 1" | 3" | 2"-½ |
| | 100 — 100 | |
| 1" | 3" | 2"-½ |
| | 100 — 100 | |
| 1"-¼ | 3"-½ | 3" |
| | 100 — 100 | |
| 1"-¼ | 3"-½ | 3" |

In conclusion, the uncertainties and irregularities of steam heating are by this apparatus largely disposed of, and its adoption insures to the heating engineer a certainty of circulation, of drainage, of absence of noise, and of efficient return of heat to the boiler, which removes a great deal of responsibility and anxiety as to results.

The problems which the extremely tall modern buildings present are efficiently dealt with by this system. Circulation, in lines of many hundreds of feet of mains and sub-mains, is to be depended upon. Exposed particular portions of the system can be provided with extra circulating facility, with or without reduction at any other part. No necessity exists for that special and nice proportioning of supply and return lines which demands such certain and careful calculation and forethought in a gravity plant.

Old and inefficient systems can be made efficient and those in which extreme back pressure has been necessary can be reduced to economical condition.

All this is due to the fact that the system operates by those natural laws which experience has shown to control the work of steam in circulation and condensation, laws which have long been recognized and successfully utilized in steam engine practice, and which demand equal consideration by heating engineers.

DISCUSSION.

Mr. McKiever:—I must take exception to some of the declarations that are made in this paper. On page 155 the author says: "The products of this condensation, being of a heavier nature than the elastic vapor, will continue their motion only to the degree to which speed is imparted to them by the travel of the steam." I think it would be necessary to qualify that statement in order to arrive at a safe conclusion. For instance, if the forces were travelling in a vertical direction we would certainly get much greater speed and it would not need the power of steam behind to cause them to move; they would act according to the laws of physics.

On the bottom of the page he says: "At this point it may be instructive to point out that the common theory of the flow of condensed water in pipes is largely in error. It is usually assumed to be drifted along at the bottom of the pipe." He further says that "the usual method of dripping pipes, especially large pipes, from their lowest level is, therefore, only partially correct." That assumption I believe to be correct, but whether the author's deductions are drawn from vertical or horizontal pipes makes a material difference. The sizes of the pipe would also make a material difference. His theory may be partially correct in pipes of very small area, but not in pipes of large area.

As to the method of dripping pipes, the experience of many has taught us that the bottom is the correct place from which to take a drip, and the area of the drip outlet should be equal to, if not larger than, the area of the pipe in piping of smaller sizes than 2-inch, and

in dripping pipe it is further advisable to make a rise at the point dripped, should it be possible to do so.

On page 157 he says: "It is a mechanical operation which drives the excluded air into the upper portions or extreme ends of radiators." It perhaps might better be stated to be a natural order of things that air should go to the highest point, not a mechanical operation.

On the same page he says: "On the other hand, any open system of drainage controlled at will by the operation of hand valves must necessarily be liable to derangement of operation by the least negligence of attendants." The day of the control of air by pet-cocks is passed. We have now in the market so many efficient air valves which do their work without the aid of man that the statement made in the paper is in no measure applicable to our modern practice.

It says here: "Having thus examined the conditions surrounding the removal of air gases, we may consider their effect upon the efficiency of the heating system." To say that the removal of the air gases is all that is necessary for the proper working of a heating system, is, I think, taking a very large place for it. Of course, properly removing air gases will not insure a properly working system.

On the same page he says: "The common assumption that steam at a pressure does more radiating work than that at atmospheric pressure is based on the bare theory of difference in temperatures." If we assume that the formulæ given by many acknowledged authorities are true, then the statement made that the increase in the specific heat of the steam does not increase its working capacity, must not be so. On the top of page 158 there is a statement to the effect that "the parting with this heat is effected by condensation and is in direct degree due to that condensation." Parting with its heat is due directly to the influence of the surrounding atmosphere, and as this increases directly as the difference in temperature increases any greater difference should show an increase in efficiency.

On the same page: "The effectiveness of any surface depends, etc., I agree with the writer in that the removal of the air is necessary, but cannot agree as to his method of doing it, that is, drawing it from the bottom, instead of removing it at the top."

On the same page, referring to "the presence of air-gases," etc., I would say that if it were possible to keep all conditions constant, it might be possible to so prepare the water as to meet the conditions spoken of by the writer, but the problem as it presents itself to me is not an apparatus depending upon certain fixed conditions for efficiency, but which should be general in its operation under all conditions. On the top of page 159 the statement quoted from another writer probably needs qualification. The idea the writer seeks to con-

vey, from my conception, is that it is possible to entirely and completely fill his system without the intervention of anything in the shape of pressure valves to aid it. The conditions assumed are all pretty finely drawn and can hardly agree with the observation of many of our best writers.

I want to further state that it is, in my opinion, possible with a properly designed apparatus, piping areas being adequate and surfaces being of a nature to secure an easy flow of the steam, to properly warm a building without back pressure, except that due to the open exhaust. The use of a back pressure valve in connection with exhaust steam warming is not an absolute necessity.

Mr. Barron:—If out of the efforts of Messrs. Barnard, Williames, Webster and Beaumont, and Mr. Paul, we evolve a new form of steam distribution more economical in heat efficiency and interest on plant, it will be very desirable. I believe something will come out of these vacuum systems yet, but I do not believe much has been done in the last few years, except changing from exhausting from the tail of the main return pipe to exhausting from the tail of each unit of heating surface. To take all pressure retarding the engines away from them is worth paying for if you are short on boiler pressure, but if you use one horse power in an engine using 20 pounds of water per horse power to push the steam through a circulating system, it is more economical than using one horse power in a steam pump that uses 80 pounds of water per horse power to pull the circulation with. As I said, I believe there is something in these vacuum systems, but no man can figure up an ordinary plant to-day and show that by the use of any of them there is a particle of economy over a pressure system, in fact they are pressure systems just as much as the ordinary systems with a back pressure valve; one works at 17 pounds absolute the other at 18 pounds absolute—that is the only difference; the vacuum people require pressure to circulate their steam just as much as the pressure people do. An able consulting engineer has expressed himself as follows on vacuum systems in a late pamphlet. Speaking of the conditions in our large office buildings he says that: "It is of importance to have the cylinder proportions of the electric light engines such that the desired power is developed with a back pressure as high as five pounds, for in American practice such pressure may be required for heating in the coldest weather. This back pressure, if originally figured on, is neither detrimental nor uneconomical, and I have not been able to recognize any advantages in the vacuum systems except where the engines or the piping were proportioned incorrectly at the outset or where the installation of the electric light plant and the use of ex-

haust for heating were after-thoughts. In these cases the vacuum systems frequently perform a useful service." The foregoing quotation expresses, I think, the general opinion of engineers who are best able from their experience to judge the problem, but I believe that the vacuum people, like all of us, are working for others and that the men who come after us may make something of the systems when the conflicting interests of patents have ceased to bother the engineers. At present the statement of the well known gentleman I have quoted tells the whole story. I would refer those looking for data on exhaust steam to examine E. P. Bates' paper, also the paper of H. D. Crane; both were read at the Boston convention of the Master Steam and Hot Water Fitters of the United States, held in 1892. Mr. Bates takes steam from a 12-inch exhaust pipe and distributes it through 27 acres of factory buildings with ¼ pound back pressure. I would advise Mr. Bolton to read Prof. Carpenter's tests made on radiators some time ago and I think he will withdraw the expression he (Mr. Bolton) makes when he says, "the common assumption that steam at a pressure does more radiator work than it does at atmospheric pressure is based on the bare theory in the difference of temperature." If I remember correctly Prof. Carpenter said in his paper on radiator tests that "the amount of heat given off increases very much faster than the difference in temperature of the steam inside and the air outside." In fact, every man knows in his own experience that a slight rise in pressure increases the heating capacity of the radiator very much, and makes a marked improvement in the circulation. Mr. Bolton should take a patent out on his system of extracting the air and gases from the feed water to the boiler. It is surely going back a great many years when a gentleman will bring such theories before an engineering society. I will not take the time to show that there is not waste of heat of combustion of boiler due to the energy wastefully expended in heating the gases contained in the water. The steam engineering literature of 30 years ago can be referred to in a discussion of this nonsense. Every ordinary working engineer who is running a modern high speed engine and a modern high pressure boiler knows from his own experience that there is no loss of efficiency in back pressure that cannot be offset by an extra pound or pounds at the boiler. Every engineer knows that a few pounds extra pressure takes no more coal practically. There is no misapprehension in the minds of students of thermodynamics on the question of the relative value of extra initial pressure on an engine piston against the use of a back pressure of equal extent; as they know that it is only a question of the mean pressure; gentlemen who argue otherwise and criticise make

a very serious mistake. In the quotation that Mr. Bolton made from Mr. Wolff's pamphlet Mr. Wolff, as a student of thermodynamics, knows what he is talking about, and Mr. Bolton takes the attitude of a special pleader, not to use a harsher term. It would take too long to reason out the problem that Mr. Bolton places before himself, and I will leave that to the others in this discussion, unless it should become necessary. My astonishment is that such statements in regard to a 20-inch engine should be seriously put before a society of engineers. The proper way to utilize exhaust steam in the present state of the art is to bring the exhaust steam into a tank which also acts as a return tank and in which the temperature of the feed water equals the temperature of the steam. The usual pressure carried in such work is three pounds. The water is then pumped back practically at a temperature of 212 degrees, so that the only work of the generators is to change it into steam. This comes as near a means of getting the exhaust steam direct from the engine back to the boiler as is possible. If we have an engine that we cannot run economically at an initial pressure of above 80 pounds where we are exhausting to the atmosphere, we can put three pounds back pressure on such engine and three pounds more to the initial pressure and such engine will run with equal economy, in fact better economy than when exhausting to the atmosphere. I would request Mr. Bolton to read Mr. Wolff's paper printed some ten years ago in the transactions of the Society of Mechanical Engineers, on, The Dynamical Theory of Heat; I think that was the title of the paper. I think that after reading it he will not be so sure that back pressure is an evil in modern high pressure engines of a single cylinder. The fact is to-day that with single cylinder engines we have pressures to waste, reversing the conditions of 30 years ago, when we could use high pressure in the engine that we could not possibly get out of the boilers of that day. Mr. Bolton's steam engineering is 30 years behind the age at the very least. The thermostatic valves of the Webster system shown in this paper have the potency of great things in them, but their value is purely potential. I venture to say that they will not operate successfully without the daily nursing of a skilled engineer; they are bound to leak continually and make the system a sucking system, instead of a vacuum system. Any man whose daily practice has been for years to handle devices where the expansion of a stem made of a compound or a metal is depended on to close or open a valve knows how soon these expansion valves wear out and how difficult they are to keep in adjustment. Mr. Bolton's whole system of hot water returns to the boiler is crude and expensive. The work done by the ordinary

methods in all our large buildings will give far better results than this Webster system. The statement that water can be lifted to a higher point than that due to the partial vacuum maintained in the system is fully equal to that statement made by the gentleman at the Centennial Exposition—that his boiler was evaporating 20 pounds of water per pound of coal. What Mr. Bolton actually does is probably to lift water from a radiator on the steam-loop principle.

Mr. Wolfe:—I think it was understood to be an unwritten law among the members of the society that patented articles should not be brought before us, illustrated in our books and used as an advertising medium. I simply rise to a point of order on that, because there are many gentlemen here who have invented valuable things who might like to have them advertised, too. I am very glad I have heard this; but it does seem to me to be out of order that patented articles should be brought before this society to be advertised by us, although I assume that if the paper is published the criticism will be published with it.

Mr. Cary:—The character of this paper, I think, indicates what the subject is very well—The circulation of steam for heating purposes at or below the pressure of the atmosphere. Mr. Bolton has taken up one system and followed it through. This is not the only system that there is in the market. There is a great deal of vacuum steam heating, so-called, being done. Comparatively little is known concerning it, and it was with a view of bringing this matter before the society that your council invited Mr. Bolton to read this paper. He comes here as a guest of the society invited to read a paper before it, and I think the remarks that have been made to-night are not at all in place for a guest.

Mr. Wolfe:—I shall have to maintain my position. I think I would be the last man in the world to insult a guest of this society. I was not aware that the gentleman was not a member. But in our society to whom do we owe the most, to our members or a visitor invited—properly invited? Are there no members in this society who have a system that would practically attain the results in another way? Is not our own member entitled to explain his system as against another? I cannot withdraw my remarks about the advertising. I remember that the subject was strongly discussed—that we should not discuss patented articles, that we were here to exchange ideas, but not to advocate the adoption or recommend the adoption of any patented article. I apologize to the gentleman as a guest for what I said, because I did not know that he was a guest. If I was rude in my remarks, I apologize again.

Mr. Harvey:—I think it was very kind of Mr. Bolton to come here

and read the paper. I do not think there is a member of this society who will receive any harm from having heard the paper, which illustrates the Webster system very thoroughly, and there is not any question but that it will do the work claimed for it. While that is the case the patents are simply on the appliances—no one can get a patent on a system. Most of these appliances have been in use for these or other purposes for over 50 years to my knowledge. I think that the advantages are very great in having a vacuum exhausting the air from all the radiators. I have in mind a number of cases where exhaust steam was used, where there was just barely boiler capacity enough to supply the engines that were being run; and yet there was sufficient steam taken from the exhaust of two 200 horse power engines to supply heat to one large foundry 600 feet long, 300 feet wide, and about an average of 20 feet high, also three erecting shops of 200 feet long, 100 feet wide. The steam was taken from the engines, run into a large receiver or tank, and from that supplied to mains supplying coils. The drips were run into a receiving tank about six feet below the ground. Under the tank a pump was attached to form a partial vacuum in the receiver; it required less steam, or less fuel, in other words, to supply those engines when the exhaust was on the coils than it did when they were exhausting into the atmosphere. About two years ago I had occasion to heat the Michigan University at Ann Arbor, where there were about 25 buildings, all heated with various systems of steam heating. The distance from the boiler house to the main building was about half a mile. The main return pipe was connected to a receiving tank eight feet long, four feet in diameter. Two pumps exhausted the air and all the cold water at first in turning on the steam, and we could get complete circulation with 2½ pounds of steam; so that the system that this gentlemen brings forward to-night I think is a grand one and well worthy the attention of every engineer. You do not have to buy Mr. Webster's patents, or you can buy them if you see fit.

The Chairman:—I should like to say that Mr. Wolfe is right in his remarks in regard to the exhibition of any patented article before the society; but this paper was presented at the request of the society and passed through our council, who pass on those things, and it would seem that those points that are shown and that are patented were necessary to the explanation of it, and it was perfectly right that it should be here.

Mr. Kent:—I should like to say something on this subject of the advisability of bringing before an association of this kind a patented invention. That question has been raised probably in nearly all the engineering societies of the world. While the American Society

of Mechanical Engineers has no distinct rules on the subject it has a custom, which is this: When a paper is offered it is considered by the publication committee entirely on the question: Does this paper present new information which our members ought to have and which ought to be recorded permanently in our transactions for reference in future years? If it happens to describe a patented invention or not, that is a matter entirely outside of the question. If, accidentally, it describes a patented thing and the publication of this thing in the transactions should give the man an advertisement such as he could get by paying $10 somewhere else, that is a trifle we do not care about. The best papers that an engineering society can get are those which do describe patented inventions, and if it tries to exclude patented inventions for fear of giving a man some gratuitous advertising, it will do some damage to the value of its published transactions. I think that this society is to be congratulated on having Mr. Bolton present his paper to-night in so far as he describes this system. As regards the system itself, I invented it myself several years ago and applied it in an establishment with which I was connected, and, shortly after I applied it, discovered that some one else had patented it and applied it some years before I used it. The reason I did not attempt to apply for a patent was that I thought the system so simple there could not be any patentability about it. But there may be, of course, a patent on some particular combination of pumps and valves and return tanks, such as that described in the paper. But the important thing described in the paper is the vacuum return system, independent of the particular apparatus. So I think such a paper ought to be read before the society, and the members ought not to be compelled to go to advertising papers or trade circulars to find out what the vacuum system is. In regard to Mr. Bolton's paper I think that all that portion where he furnishes data and descriptions is very valuable. In regard to the preliminary part of the paper I am sorry Mr. Bolton has seen fit to present it before the society, for I believe it to be full of fallacies. Others have spoken on this point, and I have no desire to punish him further.

Mr. Cary:—I will say a few words more in behalf of the council, of which I have been chairman. Mr. Kent has stated a good deal of what I would have said in regard to this matter. Mr. Wolfe raised the question that as long as we have a member in our society who is doing work of this kind, using a vacuum system, why not have him prepare a paper? He was invited by the council to prepare a paper and said that on account of the short notice and for other good reasons he would not be prepared to present a paper at the

meeting, but he said that he would be pleased to be here, and I hope that we will hear from him. And I think in picking up our transactions, should any one turn to them for information regarding heating and ventilation, if one found nothing on the subject of vacuum steam heating, I think one would consider that the transactions were incomplete. This is the view that was taken by the council, and for that reason we invited Mr. Bolton to present the paper.

Mr. Stangland:—I should like to read for the edification of the members who may have forgotten it, a resolution which was passed at the last meeting. It is this: "It is the sense of this meeting of the society that no recommendation, endorsement, or approval shall be given or made for any individual or any engineering, mechanical, scientific, or literary production. But the opinion of the society may be expressed on such subjects as affect the public welfare, provided those things do not carry with them the interests of any individual." That resolution was adopted. In other words, we do not endorse any system, mechanical or otherwise, or any product of machinery, except as individuals. Mr. Bolton's paper has been very instructive, and one who presents a paper here must expect to have it threshed out, and in that way we all get some information. If his paper is full of fallacies, there is sufficient engineering ability here to thresh them out. I think the point is settled, so far as the society is concerned, that we do not endorse this system. We do not endorse anybody's system. It is here for our instruction.

Mr. Wolfe:—I should like to hear Mr. Baldwin's views upon this matter. Inasmuch as the paper has been presented by a guest I move that the society tender him a vote of thanks. My objections were certainly not taken personally, but I should like to have Mr. Baldwin's opinion on the subject, if he sees fit to give it.

Mr. Baldwin:—I have not studied the subject sufficiently to speak on it. I came here for information, and while there may be some details that I might disagree with I am not in a position to criticise this system at all. I think the nearer we can use steam to atmospheric pressure the better.

The Chairman:—Mr. Paul, we should like to hear from you on the subject.

Mr. Paul:—I should like to ask two questions of Mr. Bolton. I should like to ask the amount of expansion that his valve has or is supposed to have, or that is used in getting rid of the water, and what is the temperature of the return? As I understand the question of taking water under a vacuum, you lose the difference in temperature between the temperature of the water discharged from the

radiator and the temperature due to the vacuum in your return pump. Also it is required to take care of all the vapor coming from that water. Of course you expand the water back into the steam when you reduce the pressure. That, of course, is governed entirely by the changeable weather, because a radiator will condense more in different kinds of weather.

Mr. Connolly:—I should like to inquire of Mr. Bolton if there is any data as to the cost per square foot of heating surface, or if there is any reduction in the cost of running the plant? There is one other point I have been looking for without success in the paper, and I must trust my memory for it. It is this: That no method has been found where a radiator valve could be graduated as it is in the vacuum system. While I am not in favor of complexity, if I had the money and the time to devote to it, I know I could devise a system in my residence as follows: Starting with a maximum pressure on a low pressure gravity job of five pounds, by running a main horizontal return pipe with separate upright returns from each radiator, with a check valve at the point of intersection of the main return for the purpose of holding the condensed water in a column until it would overcome the pressure of steam in the apparatus, then a graduated valve could be placed on the supply end of each radiator, and they would work noiselessly and be fairly satisfactory.

Mr. Hopkins:—In regard to regulating the heat of radiators, etc., I remember that some time ago Mr. Birdsell Holley, of Lockport, got up what he called an atmospheric radiator to use in connection with a steam heating system, and I doubt very much whether any of you ever saw any of those radiators, for I doubt if any were sent out of Lockport. They were made of tin conductor pipes with a top and base. The steam was admitted at the top with an index valve and the radiator could be heated down to three inches or a foot or whatever you pleased. Mr. Holley had these radiators that would stand up like a pipe organ and reach up pretty near to the ceiling if he wanted them to. There was no limit; and he could heat from say ten feet high down to within a foot of the floor. He had other radiators made, a regular pipe radiator, with a top and base something similar to the hot water radiator, and, admitting steam at the top with an index valve, he could heat down to any point that he wished. Of course there was an open return, but it was all taken care of with the drip, and such a system could undoubtedly be put in to-day, if there was anything to be gained by it, and the water could be taken care of by the common methods of pump and governor, etc. But it seems to me that when you can heat buildings such as are heated in New York to-day at half-pound pressure at the

very most on such days as we had yesterday, it seems to me that it is straining at a gnat to bother about the paraphernalia that is necessary to pump some air out somewhere. There are some of the buildings here, 15 or 20 stories, covering a vast extent of ground, with some thousands of feet—running up into 30,000 or 40,000 feet—of radiation in several hundred different settings, that have and did have yesterday a circulation throughout with a quarter of a pound pressure. Now I do not think that under such conditions as those the back pressure that is put on the engine in consequence is enough to make a man lay awake nights wondering whether his coal bill is going to bankrupt him or not.

Mr. Cary:—Some remarks have been made about the vacuum system being a patented system. I found that out once when I wanted to apply it to a system of steam heating in a large factory. We used a great deal of driven well water which we could not use in the boiler, but could for washing purposes. I got over my troubles by taking a large pipe and pumping the well water through an exterior pipe and letting it pass out to the wash house where it was used. I placed a T on top of this and introduced a pipe leading from the return from my heating mains. As my water fell we had practically what is known as the Buckley system used in connection with engine work for a condenser, and I succeeded in getting my vacuum in this way and it worked very satisfactorily. I do not think it is patented, and that is one of the ways of producing a vacuum. I suppose there are a great many others. When this question is brought before you, with a little thought you will probably be able to devise systems.

Mr. Connolly:—Is that the Cary system?

Mr. Cary:—No, sir. I did not give it any name. It is the Buckley system pure and simple. The patents had expired, however.

Mr. Baldwin:—I said a moment ago that the nearer we used steam to atmospheric pressure the better. I will go a little further and I will say that if you use steam just a trifle below atmospheric pressure it is probably a little better still. We know that to get the steam into the pipes we must get the air out, no matter whether it goes out at the top or bottom. It generally goes out at the bottom, because it is the heavier of the two (steam and air), densities being the same. Now, if a pump worked in this way will lessen the pressure and the resistance in the return pipe it certainly must be an assistance to the apparatus. The steam will flow in much easier when the air is removed. It is my opinion that pressures should not be much below atmosphere, because if they are the tendency is to draw the air in as well as the steam. I am of the opinion that the steam

should be a little below atmospheric pressure to get the best results, all things considered. As to the details of this system, the valve at the lower right-hand end of the coil shown by Fig. 46, as I understand, is nothing but an automatic steam or water trap. Steam is admitted to the radiator or coil by the usual inlet, and as the water forms and runs down to the lower part of the radiator it cools this stem or expansion piece, which I believe to be rubber in this case, or it might be a differential metal or anything else, and opens the valve so as to allow the water to flow off into a return pipe. Previous to turning steam in the radiator may have air in it, as probably it has. But the return pipe is kept a little below atmosphere, and it is simply to allow the water to run away without resistance as well as to help the air out of the coil that the vacuum is used. Water simply gravitates in the pipes, no matter whether there is air there or not. We will say the water will run in a pipe under partial atmosphere just the same as under full atmosphere. It runs in the pipe toward the lowest point and is taken by the pump and sent forward. It all hinges on the automatic outlet to the radiator and the lessening of pressure in the return pipe, which in my judgment is an advantage. The theory is correct. I am not convinced of the permanency of some of the details of construction, particularly the trap or valve. There is not a steamfitter who has done any steamfitting but knows that on an apparatus where the steam has gone down and he has an air valve on the radiator that has been closed, so that the radiator is absolutely tight, and the water is at a temperature of about 180 degrees, he will find his radiator full of steam right along, because the water is throwing off vapor at that pressure, and the radiator will continue full of steam without the water being heated to 212 degrees. I merely call that point to the attention of steamfitters so that they will see where the advantage is with a vacuum system.

Mr. Cary:—Within a year or so I was retained as consulting engineer on one of the large institutions in the upper part of this city. There were a good many old people in that institution, and old people have a great many ideas as to the temperature which should be maintained. The consequence was that the steam heating in that house, under the ordinary system, was very crude. There was a constant opening and closing of valves; one valve would be open and the other valve left closed and the engineer was kept on the constant run. They did not keep a night man, but allowed their fires to go down at night, and they wanted to know if there was not some way by which the system could be operated so that they could have their steam early on cold mornings. All kinds of air valves had been applied there, but they had not succeeded in getting anything

that worked satisfactorily. I tried this vacuum system. The engineer found that he was not obliged to get up so early in the morning. He would start up with very little steam on the boiler and yet the whole house was heated in a very short time. All complaints ceased. The valves were left in some cases, but we took the seats out of them and let them play with them as much as they wished. They are all comfortable now, because they can open and shut those valves. The system is working to-day and giving good satisfaction, and I do not know how I could have met those conditions in any other way.

Mr. Barron:—I should like to hear from Mr. Enoch Rutzler on this subject.

Mr. Rutzler:—Mr. President, I had not come up here to say anything, but merely to listen, and I thank the members for calling on me. The fact is that just now I feel the air at the top and considerable vacuum about the middle, and I should prefer to sit down. (Laughter.)

Mr. Bolton:—Gentlemen, it is always bad to have to start a statement of any kind with an apology, but I think if I had known the character of the remarks that have opened the discussion of this paper I would have prefaced my paper with some explanation of this matter. I happen to belong to the parent society of all technical societies, and it has universally been their rule that we must not look at the patentability of articles of any kind. Otherwise we shall not get any description of anything. We certainly must not describe an incandescent lamp, because Mr. Edison has a few patents on that; and we could scarcely get any scientific information of any kind, because usually when a man has a fairly good apparatus he flies off to Washington and gets a patent on it as quick as he can. Therefore I think we are fully justified in describing any patented article that in the course of our practice is found to answer certain purposes. That was the object of my paper. I had entered on the question of the circulating of steam for heat, especially in connection with these very tall buildings, which present a new problem to most of us, and it is not enough to go back ten years and say we did so and so when buildings were 100 feet high, and then try to apply those rules to buildings 250 and now approaching 300 feet high. My position was taken in the laying out of the paper, that is to say, I endeavored to lay before you the plain reasoning which had led up to a certain set of requirements which in my mind were necessary to fulfill before we could successfully deal with these large buildings with absolute certainty. Those requirements were reached on page 160. When I arrived at those conclusions I began to look around and

see what was being done. I went to see a great many of these plants that were running on half-pound pressure, and I nearly always found that they were nearer 15, 10, 8, and 6 pounds. I never saw a half-pound and I cannot find one. I should very much like to see one, unless it is one I have done myself, and those have been done with an apparatus that has pulled the circulation around. In searching for apparatus to answer these purposes you may eventually run across something that a man took a patent on. I mention it as sufficiently interesting for all members of the society interested in steam heating to desire to be informed about. In this city we have now eight or ten of the large buildings being successfully heated with the very gear in front of you, and those buildings having been laid out with that apparatus can be depended upon for circulation under all circumstances in a way that no gravity system could ever afford you. That is to say, we can get up in the morning at any time we like and start up the pump and be sure that we would pull our circulation, not only through the lower radiators, but through every radiator in every floor and all alike. A man would be a fool who did not adopt an apparatus by which he could obtain those results, merely because it was patented. I must admit when I started in to adopt a vacuum system for steam heating I did not forsee that we would obtain thereby a graduation of temperature in the radiators, but it has turned out that that is one of the most valuable features we can have. In the office building to which I have the satisfaction to point you can go into any part of the building, any particular office, and finding the temperature a litttle too high, you take a turn down on the inlet valve—you have no other to fool with, as Mr. Cary had up-town—and you get what temperature you like. In my office I can maintain a regular temperature of 80 degrees in the radiator if I want it. And why? Every portion of the radiator is a condensing surface and is equally hot. The water is removed immediately as it is formed by a natural process.

I will endeavor to answer those questions which have been addressed to me as concisely as possible.

The thermostatic valve is certainly the essence of the matter, and I want to say that as you see before you two figures of the thermostatic valve it will be evident to all of you that there are other improvements to follow. I do not doubt that if every working brain in this room was set to work on thermostatic valves we would probably get the best thermostatic valve—the one I am searching for and the one I believe the parties interested in this particular apparatus would be very glad indeed to see. The thermostatic valve as shown here is nothing but a trap. It is in fact a Jenkins' air valve

enlarged. The first one that was submitted to me for adoption was almost a Jenkins air valve, so small that I literally snorted at it because I thought it would die of inanition. I do not want you to think that those are full size, because they are not. The nature of the stalk I must also admit I am not acquainted with. It is a material that is used in the ordinary air valves. It has an expansion and contraction due to certain temperatures, and the amount of opening which it affords in the ordinary thermostatic valve is sufficient to open that little opening, which is all that is required to remove the condensation from the radiator up to as much as 100 feet of surface. Therefore that little valve more than does its work. In fact you can scarcely make the openings small enough. If you were to have a pipe less than a quarter of an inch in diameter from the radiator of 100 square feet you would find you were draining it efficiently. Of course, in practice you would naturally get a very much larger size of pipe. The thermostatic stalk might be just as well made of metal, or of any other form, and no doubt can be made to do its work in that way, but in the form as you see it there, it is the most handy that I have found up to the present.

The question of the temperature of the returns is rather difficult to handle, because it varies from hour to hour. The needs of the large buildings in which I have had to handle the work I have found to be constantly varying. I never find them alike. Consequently that is one advantage that I have been able to discover in having a flexible medium for returning the water of condensation back to the boiler. That flexible point is the return pump. You can either run that full speed, at half speed, or just make it move, and your condensation will go back just as you may desire. In fact, you can make as active a circulation as you desire and as sluggish a circulation as you may require. I should like to tell you of an instance in the Syndicate Building. The engineer in charge, after some period of working, when the cold weather came on last fall, tied his back pressure valve up entirely and took the weights off and lashed the whole thing down so that the engines, which happened to be direct connected engines, 16-inch cylinders, driving four electric elevators, and all the other pumps, exhaust into a closed system. That closed system consists of a certain number of pipes leading to a certain system of radiators. If those radiators under normal conditions were not enough to condense the steam, naturally a back pressure would result, and you may see a slight back pressure sometimes rise as the engines increase or decrease their load. Sometimes the pressure is below atmosphere and sometimes a shade above. The engineer had been smart enough to discover that by active con-

densation throughout his system he decreased his coal bill, and on moderate days, when his radiator system is not enough to condense the whole of his steam, he goes through the line of toilets and opens the windows, makes a nice draft on the radiators and so gets condensation for nothing. It has been quite rare since December to see any steam issuing from the Syndicate Building.

I should like to say to the gentleman who opened his remarks by criticising my suggestions on the draft of water in pipes it will be manifest to him if he looks at my paper that my remarks were intended to apply to horizontal pipes. Of course, in vertical pipes the condensation is driven up with the steam and falls back with the steam constantly, but it is in horizontal pipes we meet our main difficulty of dripping the drainage, and the motion of that condensation is directly due to the speed at which the steam travels and no other, and I am theorizing, I will admit, when I say that theoretically we should drip the pipe all around its circumference. That is not done in practice. But it would be evident to him if he would take a large glass tube and insert it in a line of pipe and see the steam pass through it.

It is almost hopeless for me to meet such a sweeping condemnation as Barron's reply to my remarks in saying my paper is distinctly behind the age—I think he said 30 years. That would be about when I was ten years old, as I stand now. But I must disagree with him. Another gentleman has taken me to task for not going back to the writings of another eminent engineer ten years ago. We have lived a great deal of practice over in the last ten years, and I think a great many of us would hesitate to go back ten years and do what we used to do then, and even the best of us would admit that our writings ten years ago stand in need of some improvement nowadays. My idea has been that in all our work here we are endeavoring to get up to the highest standard. We are, in the States, at the present time, ahead of heating practice in the rest of the world, and we do not want to go back to where we used to be. People who still maintain values in back pressures on engines must be certainly remarkably unacquainted with modern practice, because if there is any value to back pressure we should certainly use it on board ship, and we do not do that there. The very first thing we think about is the condenser of the marine engine, and in the radiators of these large buildings we have the finest condenser we could possibly wish for, doing useful work, and work that we should otherwise have to pay for in fuel.

I have also heard some rather hard remarks upon my having devoted so much time and attention to the removal of air and gas from

feed water. That is one of those things which is certainly incidental, but upon which in the text books I will admit that you would not find much. I had a few years ago—not ten, but a few years ago—the advantage of making tests in open boilers designed to exhibit before another society the action of the formation of bubbles upon heated surfaces in the boiler, and they were exceedingly instructive. They taught me what I had never been able to see anywhere else, and what very few engineers had noticed at any time, viz., that the first heated water in contact with the plate through which the heat is coming forms itself into bubbles. Those bubbles are very largely bubbles of air and gases, and they undergo, under the microscope, the most remarkable series of enlargements and depressions. Before they are released and rise to the surface they would probably increase and decrease in size 50, 60, or 100 times, and then eventually release themselves from the plate. But apart from that, I think that anybody who will look into the question of the specific heat of steam and of air will admit that the presence of air in water, if it is to be heated and to be boiled into steam, can be determined; to the exact extent that must affect the economy of the boiler I am not prepared to say. It would be a matter of experiment.

But I still maintain my position, and I would say that as time goes on we will be further enlightened on that and probably find out in that some of the unexplained causes of the loss of heat in the generation of steam which are certainly not fully accounted for at the present time.

I should be very glad, indeed, if the gentleman who was able to refer to a 20-story building heated at half a pound pressure would take me to see it, and I in return would be glad to take him to many others where he could find from eight to 15 pounds. But putting that apart, from the point of view of the consulting engineer or of the heating engineer, is it not better for us, when we have responsibilities to bear in laying out plans, to take a system that will give us that certainty and flexibility we want, and relieve us of the responsibility that we feel so much, and where we can go comfortably to bed at night and feel that the vapor pump is doing its work the first thing in the morning in getting up circulation?

The cost of running a plant on such a system as this, as against the gravity plant, I am not able to speak on with certainty. I should be glad, if your society should care for it, to present figures for comparison. But it is exceedingly difficult to get two buildings on parallel lines, and say this building cost so much for its steam heating and that so much. The buildings which I have at present using this system will vary, mainly because their elevator service is probably different.

I was pleased to see the modesty of Mr. Rutzler on this subject. Mr. Rutzler has put in one of these plants, and I know he is in a position to take in a great deal of information, and next year I guess he will have lots to say on the subject.

I earnestly hope that no member of the societly will think that in my reference to the writings of other engineers of greater prominence than myself I intended any disrespect to them. I took care to omit all references of a personal character or names, and had it not been for the somewhat unnecessary heat of the speaker on that subject probably the names would never have been mentioned.

I have to thank you, gentlemen, very much for your kind attention to my remarks, and only wish that time would admit of my going still further into the argumentative side of the question. The practical side is best seen by going down town and seeing the apparatus at work. All questions of advertising and patent rights should be put out of your head. What we want to get at as heating engineers, doing the best for our clients, is if we come to the conclusion we have an apparatus that is doing better than previous practice we should feel bound to adopt it.

## XXXI.

# COMPARATIVE TEST OF TWO CENTRIFUGAL FANS.

BY PROF. J. E. DENTON, HOBOKEN, N. J.

(Non-member of Society; presented by council.)

The following test made by Prof. J. E. Denton, of Stevens Institute of Technology, attracted the notice of your council who, thinking it contained valuable information, have decided to place it before the members of the society with a view of inviting discussion as to the relative merits of fans constructed on different principles.

The fan to which attention is called, you will notice, is quite a departure from the patterns we have been using in our work, and this being the case the question presents itself as to whether other departures cannot be made that will produce still better results.

The members will notice that the conditions under which this test was made vary considerably from those met with in ordinary ventilating practice, the pressures being extremely high, but nevertheless the results seem to show the comparative efficiency of the two fans.

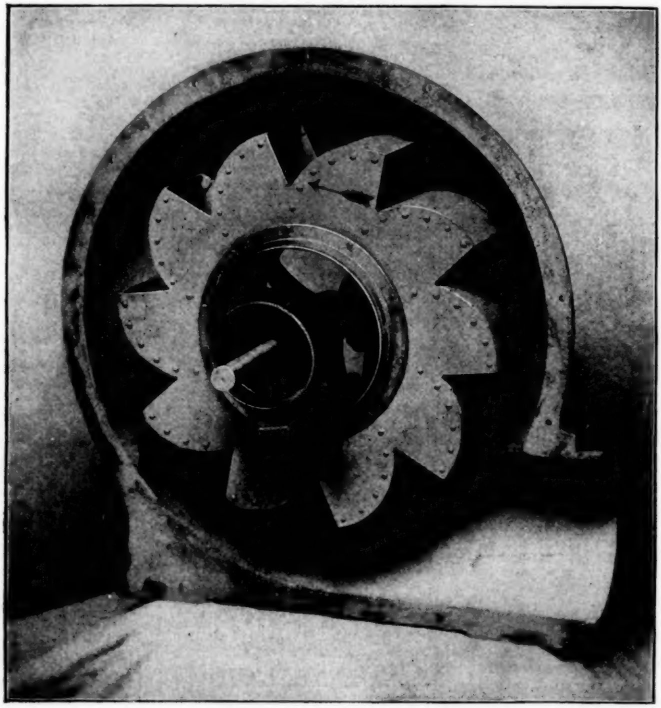
These fans are distinguished as A and B and are shown by the accompanying cuts. They are of the following dimensions:

| | A. | | B. | |
|---|---|---|---|---|
| Outside diameter of wheel | 36 | in. | 31 | in. |
| Inside " " " | 15 | " | 15 | " |
| Width of wheel at outside diameter | 6 | " | 1¾ | " |
| " " " " inside " | 6 | " | 5⅛ | " |
| Diameter of inlet on each side of fan | 15 | " | 15 | " |
| " " outlet | 12 | " | 12 | " |
| Height of case | 52 | " | 52 | " |
| Width over outside of shaft bearings | 38 | " | 38 | " |
| Diameter of Shaft | 1½ | " | 1¾ | " |
| " " Pulleys (2) | 8 | " | 8 | " |
| Number of main blades | 8 | " | 6 | " |
| " " intermediate blades | 0 | " | 18 | " |

To determine the efficiency and capacity each of the fans was in turn belted to a steam engine and driven at various speeds to main-

tain different pressures while delivering air through several sizes of conical pipes, whose areas of opening are shown in the second column of the accompanying table.

The aim was to obtain the same pressure (Col. 4) with each fan in each pair of experiments under exactly similar conditions of delivery tubes. The latter extended from the mouth of the blower over a length of from two to six feet and were conical pipes whose sides were inclined either three or one and one-half degrees to each other. In the experiments marked thus (*) the conical pipe was connected by a



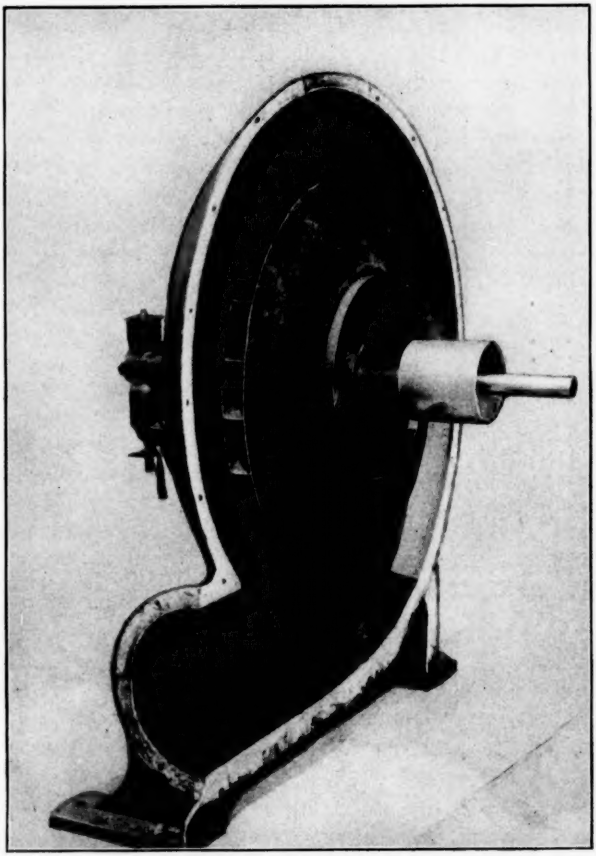
BLOWER A.—Fig. 53.

funnel to a 36-inch tube 12-feet long, at the mouth of which the velocity of the air was measured by means of anemometers.

The velocity was also measured by a Pitot tube placed in the outlet pipe about 18 inches from the blower, at a point where the cross section of the pipe was 0.64 square feet.

This Pitot tube consisted of two pieces of one-eighth inch copper pipe, which were inserted vertically through a cork in the top of the conical pipe. The outer end of each copper pipe was connected to a

water glass. The inner end of one copper pipe was bent at right angles towards the blower, so as to present a funnel-shaped opening to the current. The largest diameter of this funnel-shaped opening was one-eighth of an inch and its smaller diameter one-sixteenth of an inch. The other outer copper pipe had its inner end sealed, its sides slightly flattened, and was perforated on each side of the flattened portion by a hole one-thirty-second of an inch in diameter. This pipe



BLOWER B.—Fig. 51.

was so located that a line passing through the two one-thirty-second perforations was exactly at right angles to the direction of the current of air.

The pressure shown by the bent copper pipe is given in the fifth

column. The pressure shown by the other copper pipe is given in the fourth column. The latter pressure is that which would be shown by a pressure gauge tapped into the side of the air pipe and represents the pressure which the blower would produce in the blast box of a cupola when delivering the quantities of air shown in the sixth column, if the opening into the cupola was that given in the second column, and the pipe leading to the cupola was not less than 0.64 square foot in area, and so short and free of bends that there was very little loss by friction.

The quantities of air shown in the sixth column are calculated from the difference of pressure between column 5 and column 4 in the tests where the air was delivered into the 36-inch tube. These quantities are relatively the same as was shown by the anemometers.

RESULTS OF EXPERIMENTS ON BLOWERS.

| 1. Blower | 2. Area of smallest opening sq. in. | 3. Revolutions per minute | 4. Pressure near blower case at section of pipe of 0.64 sq. ft. | 5. Sum of Pressure and head due velocity | 6. Cubic feet of air per minute | 7. Horse power indicated. | 8. Cubic feet per horse power. | 9. Proportion theoretical pressure realized. |
|---|---|---|---|---|---|---|---|---|
| | | | Ozs. | Ozs. | | | | |
| A | 71** | 1480 | 2.2 | 6.38 | 6520 | 16.92 | 385.3 | 0.152 |
| L | 71** | 1900 | 2.2 | 6.38 | 6520 | 21.69 | 300.6 | 0.131 |
| A | 56.75* | 1411 | 2.8 | 5.50 | 5365 | 12.32 | 435.5 | 0.212 |
| B | 56.75* | 1771 | 1.9 | 5.43 | 6155 | 17.06 | 360.8 | 0.132 |
| A | 56.75** | 1333 | 3.48 | 5.37 | 4576 | 8.67 | 527.8 | 0.292 |
| B | 56.75** | 1644 | 3.35 | 5.38 | 4664 | 11.34 | 411.3 | 0.262 |
| A | 24.50* | 1500 | 7.13 | 8.29 | 3495 | 11.23 | 311.2 | 0.473 |
| B | 24.50* | 1846 | 6.96 | 8.06 | 3407 | 11.69 | 291.4 | 0.444 |
| A | 24.50** | 1846 | 13.59 | 14.50 | 3146 | 19.57 | 160.8 | 0.601 |
| B | 24.50** | 2462 | 13.59 | 14.50 | 3144 | 22.04 | 142.6 | 0.478 |
| A | 24.50*** | 1500 | 7.87 | 8.85 | 2483 | 8.37 | 296.4 | 0.531 |
| B | 24.50*** | 1811 | 7.56 | 9.15 | 2469 | 9.07 | 272.2 | 0.495 |

Average temperature of air 81 degrees Fahr.

* Connected to 36-inch tube open to atmosphere.
** Open to atmosphere at this area through 3-degree conical tube.
*** Open to atmosphere at this area through 1⅓ degree conical tube.

In the experiments marked thus ** and *** the air was delivered directly into the atmosphere. In the case the pressures shown in the fifth column by the bent copper tube were obtained when the latter was either at the 0.64 of a square foot section, or at the juncture of the delivery tube with the atmosphere. In the former position the straight copper tube showed the pressures given in the fourth column. In the latter position the straight copper tube registered zero. Hence, the cubic feet of air delivered is obtained either by multiplying the velocity due to the difference of pressure between the fourth and fifth columns respectively by 0.64 square foot, or by multiplying the velocity due to the pressure in the fifth column by the area in the second column. The two methods agree within about three per cent, and the velocity given in the sixth column is the average of the result of the two methods of calculation.

The horse power given in the seventh column is the difference between the indicated horse power of the engine when driving the blower at the speeds given in the third column, and the indicated power when the belt to the blower was removed from the engine and the latter ran at the same speed multiplied by one.

A single belt was used in all the experiments, which was laced to the same tension with both blowers.

The revolutions of the engine were recorded by a continuous counter attached to its main shaft. The revolutions of the blower were determined by a worm wheel attached to the shaft of the blower and geared to a gas meter index plate.

The relative economy of the two blowers producing the same pressure (Col. 4), is shown by comparison of the figures in the eighth column for each pair of experiments. For example, for the highest pressure common in cupola practice (tests No. 9 and 10) the air delivered per horse power is 13 per cent greater for blower A than for blower B.

The ninth column shows the proportion which the pressure realized (Col. 4) bears to the pressure which might be produced if all of the air passing through the blower was given a rotary velocity equal to the speed of the outer diameter of the wheel.

For tests 9 and 10 the figures in the ninth column show that blower A utilizes, in producing pressure, 25 per cent more of the velocity of the tips of its blades than blower B.

The general conclusions to be drawn from the experiments are: first, that for pressures varying from two to 14 ounces, and quantities of air varying from 2500 to 6500 cubic feet per minute blower A delivers from seven to 28 per cent more air per horse power than blower B.

Second, that over the same range of pressures and volumes, blower A utilizes, in producing pressure, from six to 60 per cent more velocity of its blades than blower B.

## DISCUSSION.

Mr. Cary:—This paper, coming from Prof. Denton, who is a very careful investigator, deserves some notice. It has been brought before the society with an idea of bringing out discussion and to serve as an entering wedge to bring more fan matter before the society in the future. I hope that the discussion will bring out some experiences of the members, and I hope that it will lead to papers on this subject at future meetings. If such proves to be the case the objects aimed at by the council will be attained. This fan B (Fig. 51) is of the propeller type—the centrifugal fan, with small intermedi-

ate blades introduced. This fan (indicating Fig. 50) is known as a fan of the bucket type, which you probably recognize.

Mr. Barron:—We have with us to-day Mr. Inglis, of the American Blower Company. Mr. Wendover also is here. I should like to hear from either of those gentlemen on the subject.

Mr. Inglis:—I had no idea of having the privilege of the floor in coming to the meeting. My connection with the American Blower Company is more at the business end than the mechanical. If I had had any opportunity I should have been very glad to bring here some of the results of tests which we have made with fans of all different constructions; the result has generally been a falling back to the fan of the ordinary construction. There is a good chance for discussion, I think, with respect to the relative advantages of a straight and a curved blade. Aside from that it does not seem to me that for some years there has been any radical change in the construction of fans, and I am a little inclined to doubt, in fact, I am a little surprised—although this test, I presume, is well vouched for —at the results that are claimed for it. Having had no intimation of this opportunity to speak on the subject I should hardly like to say anything further.

Mr. Barron:—Mr. President, I think the facts of these results cannot be questioned. Prof. Denton stands exceedingly high, probably as high as any man in this country. In 1880 and afterwards I was employed in the fan blower business in the West for a few years; then I came East for a few years, and I was in the employ of a leading firm manufacturing positive blowers. I can say with Mr. Inglis that in all that time I have not seen a perceptible improvement in either class of machines.

Mr. Blackmore:—A very interesting question is raised by the fact that these tests were made under peculiar conditions—conditions different from those which we meet with in ventilating practice. That is, the pressures were high, the velocities were great compared with ventilating practice, and the question arises, what would the relative values of these fans have been if only ordinary pressures, such as are used in ventilating, had been used? We know some appliances will work better under given conditions than they will under others. It may be that these conditions are assumed as giving the best results, or that the conditions were assumed knowing that they would give the bucket style of fan a better chance than the other; and possibly, if they were tested at lower pressures, the difference might not be so great. I am not well enough informed on fan construction, nor have I read enough on the subject, to determine the point, but it occurs to me as one to be taken up in discussion.

Mr. Wendover:—It has been the experience of the house I have been representing, the American Blower Company, that in the two years past we have changed our paddle wheel, or centrifugal fan, from a straight blade to a curved blade, the reason being that we believe—this, of course, was with conditions that we are working under now, a pressure of an ounce or under, for general heating and ventilating work—with a curved blade, instead of the air being carried forward and around the casing, it will tend to throw it towards the outlet, and that is the only reason, as far as I can see, why one fan can be more efficient and deliver more air than another. We are now using very largely for low pressure work the disk fan, with the propeller type of fan, and the reason we can do so is that we have a disk in the center of our fan which prevents the back-lashing of the air, which cannot be done with the ordinary ventilator type of fan, as the air will always return under any pressure whatever. With our propeller type of fan we can secure as high as a half-ounce pressure without back-lash, which is not possible with a ventilator type of fan, and the saving in power in the use of a disk fan over a propeller centrifugal fan is well known. We have made tests showing that it takes a little over half a horse power to deliver the same amount of air.

Mr. Barwick:—Will Mr. Wendover kindly tell us about how many cubic feet of air can be delivered with a propeller fan and also with a centrifugal fan of his make, so that we may understand about how many cubic feet per horse power may be delivered through a heater?

Mr. Inglis:—If I am not imposing on the privilege given here—not that I want to advertise any particular make of fan—I would say that I recall some tests that were made in our shop a couple of years ago by Prof. Cooley, of Ann Arbor, and the idea was to determine the points mentioned, and it is right in line with some of the remarks made by the gentleman here a moment ago. Of course the results depend altogether on the pressure at which you are running the fan. With a fan of the disk type there is no question but that it is of much higher efficiency at low velocities than the other type. And these tests I speak of were carried on for some days by Prof. Cooley and Mr. Jesse M. Smith, and we found that at low velocities, which are quite common in ventilating work, there was a saving of some 23 per cent in favor of the disk fan, but as you gradually increase the velocity it came down so that there was a point where they just met; one equaled the other, and then, of course, as the speeds were increased the other type of fan had the decided advantage. I am not prepared to say just to what extent.

Mr. Barwick:—What I wanted to get at is whether it is customary to heat buildings with a hot blast system at a pressure of one-half ounce delivered into the ducts. The question is: How much horse power will it take, or how many cubic feet of air can be delivered per horse power under those conditions?

Mr. Inglis:—I am not prepared to answer that question off-hand.

Mr. Cary:—Mr. Inglis has just mentioned a series of tests that were conducted at Ann Arbor, which are extremely interesting to this society. I would like very much to have such data before us in our transactions, and if Mr. Inglis feels inclined, I think that the society would be glad to enter the results of these tests as a part of this discussion. If that is the pleasure of the gentlemen present I would ask Mr. Inglis to kindly furnish us with the data concerning the tests mentioned, and I put this request in the form of a motion. (Motion carried.)

Mr. Kent:—I think there is scarcely any subject in the whole line of engineering on which engineers are less informed than on the subject of fan blowers. If we want to put up a ventilating system we can get very definite information about boilers and engines and radiating surface and all those things, but when it comes to putting in a fan we have to put ourselves entirely in the hands of the manufacturer of the fan blower and do what he tells us. This subject was brought to my attention a few years ago in trying to compile something on the subject of fan blowers for use in my "Pocket Book." After I got it done a manufacturer of blowers told me it was all wrong, that the fans and blowers would not give any such capacity as I said they would. I said, "I have got this information right from first hands. Now will you please give me the correct information with your name to it?" He said, "I cannot do it. If I did that I could not sell my fans. If I told the truth about my fans I would not sell any. When a man comes to us and wants to buy a fan we tell him exactly what the fan will do, but to print it in a circular it looks so small that the other man would make a bigger statement and get the order." Now, that is not the case in engines and boilers. I think it is very desirable that somebody, either the blower companies themselves or the scientific colleges that are making experiments, should go through a thorough set of experiments on fans and give us some definite information as to how to design them, how to shape the blade, under what circumstances to use the disk fan, and under what circumstances to use the propeller fan. I think the time has arrived when such experiments can be made much better than before, on account of our being able to drive fans by electricity and being able to measure definitely the horse power through the

volt meter and ammeter. I hope these experiments will be conducted some day, and we will learn more about fans.

Mr. Wendover:—I would say that my experience with the Sturtevant Blower Company and also with the American Blower Company is that, with respect to the tables as given generally in catalogues, it is always safe for heating engineers to cut down on their own tables just about one-half for the delivery of air. That is, I think that practical engineers, those even who are not blower men, have all come to about that conclusion, and I think it is just about right. That was confidently given to me years ago by the engineer of the Sturtevant Blower Company. He said it on the quiet, of course, but he said, "You better cut down just about one-half on the figures given in the table." As to the power required to drive a fan, it is, of course, very problematical, and as a rule we generally say to fan men that the power almost cubes as the speed increases. We have gotten out tables with the American Blower Company in the new catalogue which I think come nearer to the actual fact than any tables that have ever been published before. The other tables that have always been published are very misleading and are liable to get the heating engineer into a great deal of trouble if he follows them.

Mr. Jellett:—They say an honest confession is good for the soul. Mr. Wendover must feel particularly good just now. Only two years ago I received a confidential letter from Dr. Billings. He asked me if I had any rule by which I deducted from fan maker's catalogues and got at the real truth. He said: "I have been carrying on a good many experiments, putting in blowers in different buildings. Of course I do not do the mechanical part. But I have been pretty badly caught several times, and I thought possibly you had gone into it more than I have." Well, I could not answer that question very clearly, because I had found anywhere from about 35 per cent to about 72 per cent over-rating. I found more than 50 per cent in a good many cases, but I guess 50 would strike about the average. I made one test a short time ago. The fan makers' catalogue showed me at that at a given speed I should get 68,500 cubic feet of air. I had the blower delivering perfectly free. I gave it an inlet supply of twice its area. Every condition was favorable. There was plenty of outlet, and the most I got out of that blower' by giving it a fair test, counting speeds every minute, having a speed indicator on it, taking the anemometer and moving it from point to point, and taking a series of readings over its face, then taking the sum of those readings and dividing by the number of tests, I found that I got a little over 38,000 feet of air, instead of 68,500. I then

coupled up a system of ducts. The area of the ducts was greatly in excess of the area of the fan. There was a constant widening of areas. Then I measured the registers all over the building. I think there were about 78 separate registers. I took a series of readings over the registers themselves, and I found a loss of nearly 4,000 cubic feet, so that I was actually getting about 34,000 feet from my registers and a little over 38,000 from my fan, instead of the 68,500 that I had hoped for.

Mr. Wendover:—I want to say, gentlemen, you do not want to consider that all the blower men are liars from the representations in catalogues. There is one point I did not mention to you, viz., that a fan man in estimating on the capacity of a fan makes his measurements by an anemometer placed at the discharge of the fan, blowing into open atmosphere without friction. You can imagine what the friction would be going through a long line of ducts. It is now the common practice of blower men to generally increase the area of the ducts over the discharge of the fan in the neighborhood of from 20 to perhaps 35 per cent. That, of course, reduces very materially the friction in the supply of air to the different rooms.

Mr. Barwick:—Mr. Jellett, was the fan that you speak of connected to a hot blast coil of similar type to the Sturtevant or others at present in the market, or was it direct from the atmosphere into ducts supplying radiators at different points of the building?

Mr. Jellett:—The blower was drawing through a heater and delivering free at the time. But the sectional area of that heater was carefully measured. The inlet of the fan was 11 and a fraction square feet. The actual clearance through the coils was nearly 22. I think a great many fan systems of heating fail, not through inefficiency of the blower, but through improper proportioning of the areas through the heater, and that is not a mistake made by heating contractors; that is a mistake more often made by the manufacturers of the apparatus. I was called in a short time ago by the owners of a large machine shop heated by the blower system. They told me that their system was not heating the shop properly, and they wanted me to put two more sections on the heater. I said, after a careful examination: "That is not what you want. You want a widening of the heater." They said they did not think so. I figured the area through the heater and the area of the inlet of the blower, and found two-thirds the area through the heater that there was in the inlet of the blower.

I find that the spacing in standard sizes of fan heaters varies. You ask for a 250 foot heater and nine times out of ten no attention is paid to the area through the heater and the area of the inlet of the

fan. I have seen many that have actually failed for that one reason. I have widened the heaters and I have accomplished the results, because the blower was ample to do its work and could not get its full air supply.

Mr. Barwick:—Have you found that, starting from the intake of the cold aid to the chamber before entering the fan, you can go beyond 25 pipes?

Mr Jellett:—I usually use 24.

Mr. Barwick:—You find at 24 pipes that the fan will deliver about 50 per cent. That is the point I wish to get at, in a certain sense. I also wish to get at the amount of air that could be delivered under ordinary conditions with a one horse power in driving a fan. I have been told that 2,000 feet can be delivered with one horse power. I have also been told that 3,000 and 4,000 could be delivered.

Mr. Inglis:—I will put you on the track of the information you want. I think there is one of your members, who unfortunately is not present this afternoon, who could throw a great deal of light on the subject. I refer to Prof. Carpenter, who has made extensive tests on all these points that have been discussed. I conceive that anything coming from such unreliable sources as manufacturers of blowers and heaters would not go, you know. (Laughter.)

Mr. Barwick:—What I was trying to arrive at was something approximate, so that the ordinary contracting engineer would be able to state, if a party came to him and asked him about how much it would take to heat his building, that it would take just about so much.

Mr. Kent:—If I was going to solve that question I would go to the blower manufacturers' catalogues and get their figures and deduct 50 per cent. But as nearly as I can figure from memory now, one horse power will drive, say, from 1,000 cubic feet a minute to 20,000 or 30,000, depending chiefly on the size of the fan and the pressure. If you have a very large fan, well hung and with little friction, and revolve it slowly, you will have an enormous amount of air passing through it, while if you try to get a little fan to do the same work it will take a good deal more power than you expect.

Mr. Barwick:—That is under ordinary conditions, such as the fan people are putting up at the present time.

Mr. Kent:—Ordinary conditions, I understand, are not at all uniform.

Mr. B. H. Carpenter:—I should like to give my experience some time ago on this question, trying to get the horse power to drive a certain amount of air, and in a conversation with the representative of one of the oldest blower houses in this country, referring to his

catalogue, I asked him if a fan at four horse power, as it was scheduled, would throw the amount of air shown on the table? He said: "It does not say that the fan will throw that much air at four horse power." At the end of the table it gave the size of the fan and above one column the amount of cubic feet thrown; in another column the revolutions of the fan, and in another column "horse power," and under that it said four horse power. He said: "Well, our fan will revolve at four horse power, but we do not say it will throw that much air."

Mr. Kent:—I should like to ask Mr. Jellett, in regard to the arrangement of coils, whether if he had a coil, say, of 200 vertical pipes, ten in one direction and 20 in the other, it would not be better to put them broadwise, so that the air would pass through the broad dimension.

Mr. Jellett:—Yes, you would find less power, but it would not meet your requirements of heating. From my experience you must have the air in contact with a certain number of pipes to get the temperature required. I have made tests with from 16 to 24 pipes in depth on the basis of zero weather, and with zero weather and 20 pipes in depth you will get in the neighborhood of 165 degrees. If you put in 24 pipes you will only gain two or three degrees in temperature. The real object in putting in the 24 pipes is that you want one section for reserve. But I always figure the areas in width and height to give myself plenty of clearance through my heater, because if the fan is checked at all you cannot get your results, and you can do better work with a small blower with the air at a high temperature than with a large blower with the air at a moderate temperature, because there is the loss of temperature through the system of distributing ducts. There is one thing that the fan makers, so far as I know, have never yet touched in fan systems of heating, and that is a series of tables on the loss due to a loss in temperature in a system of ducts. But my impression is that there is less actual loss on the fan heating system in friction than there is in temperature and increased weight of air to be moved due to drop in temperature. Now, I had that called to my mind in a college building some time ago where my ducts were some 300 feet in length. The contract did not require us to wrap the ducts. The loss of temperature was 30 degrees. I started at 165 degrees, and the most I could get at the other end was 135 degrees. That loss of temperature, plus the increased density and plus the air moved, means more in my mind than the friction of a properly proportioned system of galvanized iron ducts, and I do not know the fan maker that has ever published data on the loss due to the loss of temperature. I think it is really a

more serious problem than the question of friction. I have taken the area at a given temperature of air, 70 degrees in summer time, put up a system of ducts for ventilating purposes, and had very little loss, indeed, due to friction. I have taken the same system during its run in cold weather and had a very decided difference in loss.

Mr. Barron:—We have with us here to-day Mr. Crosby, from Prof. Woodbridge's office. I should like to hear from him his experience in fans.

Mr. Crosby:—The questions that have been asked here call to mind a small school that I had occasion to test a short time ago. In that school we had figured to give a supply of about 25,000 cubic feet of air per minute. An 8-foot unhoused blower type of fan was used. It is the form that has been developed by Mr. Woodbridge, using the Meigs-Briggs forms of fans as a basis. Assuming this unknown quantity of friction that you have to guess at, I think we expected to run the fan at about 125 revolutions to do the work. In this particular school the fan was set up in a large interior room under the main corridor, so that the air was delivered directly into the room, making a large plenum, and out of the sides short horizontal ducts were taken to the foot of the flues. When we came to test that school by the anemometer I found that on a day when the outside temperature was about 26 degrees and the fan was making 110 revolutions, there was something like 31,000 cubic feet of air per minute going in through the inlets. That air was drawn through a coil seven pipes deep. The coils were made of 1-inch pipes spaced 2½ inches apart. If there is any data there which will answer any of the questions that have been raised, I am sure you are welcome. The engine, by the way, was a 6 by 10 vertical engine running under about, as I remember, 24 pounds boiler pressure. I have not figured out the horse power developed, or anything of that kind, but I think perhaps from the data some one can figure it out.

Mr. Barron:—We have a gentleman here who has used thousands of fans in school work, and I should like to ask him to say whether he thinks the disk fan or the blower fan is worse. I refer to Mr. William McMannis.

Mr. McMannis:—I must say that I have had great satisfaction with both types. With the disk fan I have had good results and also with the blowers.

Mr. Barron:—You never have had any particular difficulty in getting at the capacities have you?

Mr. McMannis:—Not at all.

Mr. Barron:—Now, Mr. Chairman, I have a little something to get in our record; that is, a definition of terms. We are evolving

a lot of terms here, and there is a lot of misunderstanding from time to time in the use of terms. Mr. Barwick says "propeller fan," referring to what is commonly called a disk fan. Both terms are absolutely correct, because a propeller fan means the same as a disk fan. He also uses the term centrifugal fan, meaning by that a fan blower. Now both terms are absolutely correct. What I want to get at is this—that a screw fan, such as is used in Dr. Reed's work, is a different machine from either of those mentioned, although, of course, on the same principle as a disk fan. Mr. Wendover, if I understand him aright, said that the power required to drive a fan increased as the cube of the velocity. I think that is it.

Mr. Wendover:—Yes, sir.

Mr. Barron:—Twenty years ago I was laboring in a ship yard, and I think that we used to figure then that the power required to drive a ship also increased as the cube of the speed.

Mr. Cary:—I see that Mr. Stangland has just come in. I am sorry he was not here before to hear this discussion, but I know he can tell us something about the propeller type of fan—the disk fan.

Mr. Stangland spoke briefly but he could not be heard by the reporter.

Mr. Barron:—The business of making disk fans is on the increase, is it not, in your opinion? That has an important bearing on this subject. (Laughter).

Mr. Stangland:—It would seem so.

# XXXII.

## TOPICAL DISCUSSIONS.

### THIRD ANNUAL MEETING.

### Topic No. 1.

Can oil or gas fuel be used to advantage in heating dwellings?

Mr. Kent:—Gas has been used for fuel for a good many years in Pittsburg and other Western towns. The only question is to get your gas cheap and then it is practically fuel. Oil can also be used, but generally it is rather more expensive than coal. There can be no doubt at all that we can use either of them if we can have them cheap enough.

Mr. Harvey:—In the city of Detroit we have natural gas that is very reasonable in price. It is 30 cents a thousand cubic feet. I find that for cooking it is cheaper than hard coal when used in an ordinary kitchen range. I also have two boilers in my house; one I use with hard coal and one with gas. When a little heat in the mornings and evenings is required we use the gas boiler and by turning off the gas as soon as the house is sufficiently warmed the consumption of gas is immediately stopped. When heat is required for 24 hours then the hard coal boiler is used, which in this case is more economical for a continuous fire.

Mr. Miller:—In using gas as a fuel in houses a question as to its economy arises. My opinion would be, without experience, that in the first installation of the plant the gas heater could be made the most cheaply, but after that a question would arise in regard to the gas bill. When the gas is burned we are through with it. But when the coal is burned there is a great amount of expense and wear and tear and other things that have to be considered. The question that occurs to me is whether the people should be educated up to paying $1\frac{1}{2}$ or twice the amount for heat right along, even if it cost that. But, on the other hand, gas is a thing that can be regulated so readily, that it is a question whether it could not be utilized in such a way as to bring the cost down very close to what it would be with coal, or, say, $1\frac{1}{4}$ or even $1\frac{1}{3}$ times what it would be with coal. I

know a great deal of attention has been given in the last year to this subject of heating houses with gas. Another point that may come up later on in this connection is in regard to the quantity of water; whether in heating houses it is necessary to put an immense quantity of water in them; whether it is not better to circulate more rapidly and use a less amount of water. That might cut some figure in using gas—whether, by using a smaller quantity of water, the gas could not be used.

Mr. Harvey:—I think I can make a suggestion that may give you some idea about that. I have tried the different kinds of boilers with gas and with coal. I have found that a pipe boiler, made so that the flame of the gas would come directly in contact with the tube and the tube being full of water (in other words, I took a piece of 12-inch pipe and put 1-inch pipe, tapped in porcupine style around it, then arranged deflectors in such a manner as to bring the flame in contact with all the 1-inch pipes, which were exactly one foot long, the water being inside the 1-inch pipe and circulating inside the 12-inch pipe), was better than the tubular or flue boiler. When the water tube boiler was fired with coal I did not get as good results as I did on the tubular boiler. But I adopted the water tube boiler, because it gave the best results with gas, and the reason we use the gas boiler in the fall and spring is simply because we require a little more heat in the morning and in the evening, and it is easily started and steam is generated very rapidly, and after having the house warmed the gas can be at once shut off. That is where the greatest economy comes in—simply in the rapidity with which we get the house heated and the gas shut off, stopping the consumption of fuel as soon as the desired result is accomplished. In the cooking range the saving is in using the heat only for the purpose for which it is required. For instance, if you want to boil water in a tea kettle you just have one burner under it; if you want to heat the oven you have one burner for that, and one independently for the water front, whereas, if you were burning coal, you would have your whole fire-box filled, and the consumption of fuel would be going on continuously.

Mr. Miller:—This brings up just the point I had in mind a moment ago, viz., by close regulation of the gas, which is entirely practical, wouldn't it be cheaper to use it all the time? This gentleman says that his experience is he could use it two or three months in the winter to great advantage. The question comes up as to whether he could not keep this fire going right along for the entire winter and run it for very little cost over what it costs to run a coal fire, if he had to keep a coal fire going all the time, which he would have to do,

while the gas could put itself out. Can we not make gas self-governing? I expected to have a device of that kind at the meeting, but I did not get it quite ready; but by controlling the gas can we not heat our houses with gas and avoid all the trouble of ashes and coal and servant girls?

Mr. Harvey:—You will find that where you have a large quantity of heat to produce continuously coal will be cheaper.

Mr. Wolfe:—The question is, can we use it with advantage? Gentlemen conversant with the West know that they not only can but do use gas, that is, natural gas. It is perfectly safe to say that the coming light will probably be electric. Every large city and town in the country that has a gas plant must utilize that for some particular purpose. For illuminating purposes the market for gas is growing decidedly less every day. I am informed by a gentleman who I believe is a competent gas engineer in a position to understand what gas costs, that a gas can be manufactured which is perfectly good—too rich for illuminating gas, but perfectly good for cooking and heating purposes at about from 18 to 20 cents per thousand feet. Take the best construction of Bunsen burner to-day and I imagine that for every 20 feet of gas you burn you utilize the oxygen of about 80 feet of air. You are utilizing the air and you are not burning so much gas, and if gas can be produced at from 18 to 20 cents and sold from 50 to 75 cents, and we can utilize a good burner that will take 80 per cent of air, why is it not cheaper than coal? It must be so, particularly in the East. You take it all through Indiana and Ohio and they burn gas. Gas is the coming fuel in my judgment, as far as I can see, because they are getting down from $2.50 gas to $1.00 gas, and they give you a range to burn it with, and for illuminating purposes gas is pretty nearly a back number.

Mr. John Gormly:—It may interest the society to hear of an experiment which I tried two years ago. The price of gas was reduced in our city to $1.00 per 1,000 cubic feet. At the time I thought it well to see whether we could utilize the gas under heating apparatus where coal had formerly been used. I made some tests and found that with gas at $1.00 per thousand cubic feet, and with bituminous coal at $5.00 per thousand pounds it would cost just ten times the amount of money to heat with gas that it would to heat with coal. I made the test by weighing and evaporating a definite amount of water. I made the test twice to be certain that no mistake had been made. The results were identical in each test.

Mr. Wolfe:—What class of burners did you use?

Mr. Gormly:—I used a Bunsen burner of the regular pattern. I had a perfect flame, with no unconsumed carbon.

Mr. Wolfe:—A perfectly blue flame?

Mr. Gormly:—Well, it was rather a purple flame.

Mr. Kent:—My own studies on the subject entirely confirm what the gentleman has said, that with the cost of coal at five dollars a ton and gas at one dollar a thousand, the gas is about ten times as expensive as the coal. I have made a calculation showing that when New York city illuminating gas sells at $1.25 per thousand cubic feet it is equivalent for heating purposes to anthracite coal at $40 per ton of 2,000 pounds.

The President:—It might be interesting to know that during the last year I have had tested one or two gas producers. Producer gas usually contains about 150 heat units per cubic foot and we should get nearly 100 cubic feet of gas from a pound of coal; we actually get about 60. This indicates a waste of fully 40 per cent in the best producer that I have known. That puts the gas, to begin with, just about on the basis on your ordinary heating apparatus. In other words, you can burn your coal and you can utilize about as much heat from it right in your house as you can convert into gas. Consequently, for heating purposes, where you can use the heat to as good advantage as you can in a steam boiler, I do not believe that manufactured gas can ever come in competition with coal. When you are burning fuel with coal stoves, instead of under a boiler, the question is different, because you can burn gas there with a greater efficiency than you can coal. The wastes are less.

Mr. Hopkins:—Some three or four years ago I examined the heating plant in the city of Buffalo, where they employ natural gas as the source of heat. It was an apparatus especially designed for gas burning—a hot water plant with boilers having very small water ways, holding the least possible quantity of water that it was practicable to get in them, with small mains, the pressure carried being about five pounds. The whole apparatus was designed in every way to get the least possible quantity of water in it. The natural gas was sold at 75 cents per 1,000 feet. At that price the owner—a man known by most of you, Mr. Harris, of the Standard Radiator Co.—estimated it was just equivalent to what it cost to heat the house with anthracite coal at the prevalent price of $4.75 a ton. I went over the matter pretty carefully with him and verified the figures so far as possible without making the actual tests, he giving me the quantity of gas consumed by meter measurements, and I estimating the amount of coal that would necessarily be consumed to supply so many feet of radiation. But the secret of the

results obtained lay in the small amount of water that was used to convey the heat units to the radiation. With a boiler with large water ways, apparatus with large piping, and all that kind of thing, designed for low temperature heat, with large bodies of water to move, it would probably have taken a very large amount of gas, more than what was used there.

Mr. Fish:—Will the speaker state the conclusion at which he arrived as to whether the gas was the cheaper?

Mr. Hopkins:—It was about equivalent to coal at $4.75 per ton. To get a clear idea of the apparatus I would state that the owner had three little boilers that stood on a shelf about two feet high, and in the morning he would start all three boilers, shut off one, then another. The burners being in sections, the full amount of heat could be used to raise the temperature at the start, only one or two boilers being used afterward to maintain the heat necessary. If gas is to be used as fuel, there will have to be some radical changes in the construction of boilers adapted for that fuel.

Mr. Barron:—Mr. President, I understand you had something to do with gas tests at Syracuse. Can you give us any data on the subject?

The President:—Not regarding the Syracuse tests; no, sir.

Mr. Barron:—In answer to the question, "Can oil or gas fuel be used to advantage in heating dwellings?" I would say that I do not think oil can, because it is too troublesome. But I think we are nearing the time when nothing but gas will be used. I use gas altogether for cooking. In the same flat where I live they have gas logs through the house for heating. They do not use them. You cannot use gas in that way. I asked a superintendent once why he did not use gas under boilers. He said that was ridiculous. I tried that on another gas engineer and he expressed the same opinion. Of course that confirms what has been stated here, that gas is too expensive to compete with coal for power boilers. I believe oil will be the fuel very soon for power boilers. Of course, this is not considering natural gas at all, but manufactured gas. I think manufactured gas could be almost applied economically to heating boilers for flat houses and dwellings. Apparently the first cost is too much. That is the case in all advances, I think. But eventually we get better results.

Mr. Hopkins:—I would state further that a few years past I knew of contractors for the erection of gas plants whose contract required as a guarantee that they should deliver gas into the holders at a cost of 20 cents per thousand cubic feet. While this was never published and probably not generally known, it was the condition required and complied with.

## XXXII.—Topic No. 2.

What is the best method of piping or connecting radiators in a hot water system to produce uniform results on a plant with long extended mains?

No discussion.

## XXXII.—Topic No. 3.

What is the highest temperature that can be maintained in a hot air furnace without detriment to the air passing through it?

Mr. Barron:—I should like to ask Mr. Blackmore to discuss that question.

Mr. Blackmore:—I am not at all able to answer the question. I know that if you do not produce a velocity of air over the furnace sufficient to take the heat from it as it is generated by the coal, the heat will go up the chimney. There is a chemical question involved as to how high the temperature may be without vitiating the air as it comes in contact with the heating surface. I am entirely unprepared, either experimentally or otherwise, to answer those questions satisfactorily. I know the natural assumption is that oxygen is vitiated or burned if it comes in contact with very hot surfaces. Just at what point we can stop with safety I cannot say. Some have said that even steam temperatures, that is, 212 degrees will, to a certain extent, vitiate oxygen. I am inclined to think that is an error. I am inclined to think we can go to much higher temperatures; but I have made no practical experiments, and I should like to hear from others on the subject, and as the discussion goes along some things may suggest themselves to me that I can talk about.

Mr. Barron:—I referred to small furnaces only. I think this topic refers to residence heating. Mr. Billings speaks of an experiment of a very air-tight furnace being turned upside down and filled with water and the water stayed there for about one second. And I should like to hear whether that is still the condition of tight furnaces, because on that depends very largely what temperature you can carry in your furnace.

Mr. Kent:—I think probably all that is really known on this subject will be found in Dr. Billings' book. As to burning up oxygen, I do not believe in it, but what we do burn up when we get to temperatures above 212 degrees is some of the noxious bacteria in the air and some of the fragments of dust that are flying around. We can convert the living bacteria into dead bacteria, which are harmless, but have a bad smell, and it is not because the oxygen has been burned out.

Mr. Blackmore:—How hot would you say you could safely make the furnace without producing those noxious smells?

Mr. Kent:—Three or four hundred degrees, I should think.

Mr. Wolfe:—I think it is generally admitted that you cannot burn the oxygen from the air, except it is submitted to a live flame. The trouble with an overheated furnace—I say overheated, meaning when it is red hot—is that, as the air in the cities contains a large amount of dust from the pavements of the street, these particles in coming in contact with a red hot surface are burned, not necessarily to the detriment of the health of the people, but the result is usually obnoxious. I have forgotten the exact degree of temperature at which this action takes place, so I will not attempt to name it. In an ordinarily well-built building (I am speaking now in the line of ventilation, not having had much to do with housework in so long that I do not know much about it) the difference in temperature, with the outside temperature at 32 degrees, will be about two degrees per minute; that is, allowing for the cubical contents of the room, if the air is passed through in ten times, the temperature at the outlet and the temperature at the inlet will vary from 16 to 20 degrees. So that, to maintain in a school room a temperature of 70 degrees, we must introduce the air at 90 degrees, and under such conditions as I have seen it never has been necessary to introduce at over 130 degrees. Otherwise, you cannot supply the 30 cubic feet of air per minute and keep the temperature down to 70 degrees.

Mr. Blackmore:—The question probably was raised to get at the comparison between the surface used for steam or hot water heaters and that for hot air furnaces. I have made some observations in school heating, and whereas we would use about 300 square feet of radiation to heat an ordinary school room, I find that furnaces doing the same work probably do not contain more than 50, 75, or 100 square feet, varying according to the furnace. If it takes 300 square feet to heat the air by steam at 212 degrees, and the furnace has only 75 feet to do the same work, the natural assumption is that heating surface of the furnace must be heated up three or four times as hot as the steam radiator, which would place it at a pretty high temperature—800 or 900 degrees, probably higher. I thought possibly that in the discussion of the question the point would come up as to whether, when furnaces are heated up to these high temperatures, the air would not be somewhat vitiated by contact.

Mr. Wolfe:—I think, Mr. President, that I understand why the theory spoken of exists. I do not know that I can explain it so that I will be understood, but I look at it in this way. I will admit right away that the fire pot and live surface of the furnace is above 212 degrees. This is above the steam radiation as to temperature; but

we do not hold our air in contact with this surface. If we should take the air and hold it in contact with the furnace heating surface we would more likely raise the temperature of the air to 500 or 600 degrees; but, air being quite elastic, the moment we raise its temperature a degree or two it begins to move and gives place to the fresh air that is coming in. Consequently, the air is in contact with the heating surface for the smallest part of an instant; it travels quickly and no air stays in contact with the heated surface long enough to attain anything like the degree of temperature that the furnace itself has. I do not know whether I have made myself clear or not. For instance, if we were passing a large body of water very rapidly over a surface heated up to, say, 600 or 700 degrees, the water would not be boiled; it would simply be warmed.

Mr. B. H. Carpenter:—It seems to me that in this question we are trying to see how near the fire we can get without being burned. Concerning the question that Mr. Blackmore brought up, I agree with Mr. Wolfe that the air passes over the heated surfaces so rapidly that it does not become heated to any great extent, if the furnace is well planned. The air passing over a steam radiator which is heated to 212 degrees does not itself exceed a temperature of 120 or 130 degrees at the hottest. Trying a case last week, with a thermometer directly over a stack of indirects, I found it to be about that ratio, and, on the other hand, heating the furnace as hot as I could, but having a good fresh air supply going over it, I did not get over 130 or 140 degrees. I have forgotten just what it was. In a certain building I was trying the experiment of revolving the air, the arrangement being such that I could return the air from the room into the basement, and over the heaters and back again to the room, to see what amount of air I could bring around and at what temperature. In other words, I was trying to see how many cubic feet I could change by revolving it at one degree, in comparison to running it on a gravity system in the same building, and seeing how many cubic feet I could bring into the room at a change of one degree, and also in comparison with the fan. But, when revolving the air from the room back to the heater, the temperature was too high, reaching 185 degrees, and it smashed the thermometers before I could get the temperature. And when I put on the gravity system it ran to 143 degrees. That was the highest temperature I had, forcing the furnaces just as hard as I could. With the fan, forcing over more air, I did not get over 115 degrees. This test was made in four rooms of an 8-room school building, where it was so arranged that I could return the air to the fresh air box. I had three systems; I could revolve the air, use the gravity system, or use the fan.

Mr. Barron:—What was the size of the grate?

Mr. B. H. Carpenter:—I do not remember just what the size was now. I meant to have the data down, but could not, in the first place, by reason of the breaking of the thermometers, and in the next place the foreman did not keep up his fires in the latter end of my test.

Mr. Cary:—I think, after hearing the discussion of this topic, that it might more properly be split up into two or three. The highest temperature that can be maintained in a hot air furnace without detriment to the air passing through it depends entirely upon the circulation of air we have. If we shut our air right up with our furnace, we are going to heat it to very high temperature, but if we have an ample circulation the temperature of the air may be raised but a few degrees, so it is a question of circulation. Then, again, the question will come up, to how high a temperature can we raise our furnace without destroying it? Also, how high we can raise the temperature of the air that is to be used through buildings without detrimental effects to health and to ventilating purposes? The temperature to be maintained in a hot air furnace does not govern the temperature of the air. That is merely a matter of circulation, and if we get above a certain temperature we experience a hot, burning feeling. Plants, if distributed through a house, are destroyed and people experience a languid feeling, and the air soon becomes malodorous.

Mr. Wolfe:—We will assume, for the sake of argument, that the man who sets the furnace knows his business. If we allow on the line of expansion from 10 to 20 per cent, we have given that furnace all the air that it will take care of. When you come to talk about at what degree you can with safety pass the air through into the building, why the question arises as to what kind of a building? You take a saw mill and I guess it would be all right at 600 degrees. But, if it was a dwelling house, when there was no particular method of ventilation, excepting that from leakages and an occasional fireplace, you could not have a temperature above 150 or 160 degrees.

Mr. Barron:—I would ask that Mr. B. Harold Carpenter give us a short description of the school he mentioned, the size of the flues, and how the work was done.

Mr. B. H. Carpenter:—I am very sorry that my experiments were not more successful. I will tell you what I was trying to do, but did not accomplish. It was an 8-room building, in four rooms of which I was making the test. It was heated by two warm air heaters. The flues were so constructed that I could use a gravity system, or I could use a fan, or, for night work, simply to warm the building when there was no one in the rooms, the air, by changing the dampers, was

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brought into the rooms and passed down into the basement over the same furnaces and up around through into the rooms again. My idea was to take the size of the flues, use the anemometer to get the speed of the air and multiply these together and get the number of cubic feet brought into the rooms every minute. Then, by multiplying the product so obtained by the difference in temperature between the air as it came out of the register in the room and the air entering the furnace, I would get the number of cubic feet that were heated one degree; taking four rooms in the same way I could get the number of cubic feet that were heated one degree from two heaters and in that way compare the different systems, one with the other, to get the results of the fan system, or the gravity system, or revolving around. The rooms were not running regularly at this time. We drew off the deflecting dampers, so as to give it a free passage. The flues on the first floors were 4 1-3 feet square; on the second floor they were five square feet, running to the rooms. On one room I had 318,318 cubic feet heated one degree; in another room, 270,840; in another room, 128,700; and in another, 176,000. These results were obtained with the gravity system. When I came to work the fan system on the same plan I found that the temperature was getting down, so I went downstairs and found that the fireman was not keeping up his fire. It was getting late at night, so the test really did not amount to a great deal. The result of it, as it came out, was that, with the gravity system I was getting 893,858 cubic feet heated one degree, and with the fan 753,994 cubic feet heated one degree; so I was getting more with the gravity than with the fan, which of itself showed that the test was not right, because I should get more with the fan than with the gravity system.

Mr. Wolfe:—Couldn't you account for the error in this way—that the upper flues were larger in area than the lower ones, and consequently the hot air would travel more rapidly?

Mr. B. H. Carpenter:—I took a test in each of the four rooms on both plans.

Mr. Wolfe:—You say you got very much more by gravity than you got by power. I notice there that you had five to the second floor and 4 1-3 to the first.

Mr. B. H. Carpenter:—The reverse of that—five feet to the first and 4 1-3 to the second.

Mr. Wolfe:—Then I misunderstood your reading.

Mr. B. H. Carpenter:—The second floor flue was the smaller, and this fan was run by a gas engine.

Mr. Barron:—What power?

Mr. B. H. Carpenter:—It was very much larger than necessary—

about seven horse power. It was on an 8-room building. I was only using four rooms in this test.

## XXXII.—Topic No. 4.

What is the value of radiant heat in the fire-box of a boiler?

Mr. Kent:—I should like to ask Prof. Carpenter, if he were here, what he teaches his students about this subject, because in the books there are statements made by Péclet and others in France about what was found in their experiments, but we are beginning to doubt a great many of those experiments and to take much of what is written in the books with many grains of salt; and one of these things is the value of radiant heat. It is generally stated by the manufacturers of boilers which have large fire-boxes that there is a great deal in this radiant heat; that you want to get the greatest amount of heat in your fire-box and the least in the tubes. That may be so. But in quite a number of experiments I have made I found that with bituminous coal you can get along better without any radiating surface in the fire-box; that is, by putting a fire-brick arch over the grate so as to entirely protect the boiler from the direct radiant heat from the coal. Our experiments on that subject are entirely inconclusive. We do get along in practice just as well with boilers that have no surface exposed to the direct radiation of the coal as we do with others, especially with bituminous coal. How it is with anthracite coal I do not know, because I know of no experiments made with anthracite coal in which an arch was put over to protect the boiler from the radiant heat.

Mr. Barron:—I do not think I can say very much in relation to the relative value of radiant heat as compared with convected heat, but I think the nature of radiant heat ought to be discussed. If the theories of physicists are correct we are surrounded by an ether that is denser than the densest steel. The accepted theories of light are based on that deduction. If those theories are correct that must be true. In the fire-box of a boiler, then, there is something that conveys these rays of heat. There is a substance, a thing, or a vibration that goes from the incandescent body of fuel to the exposed fire-box surfaces. I think it is an accepted thing among the old style of locomotive engineers—not the constructing and designing engineers, but the old engineers that pull the throttle—that 12 square feet in the tubes is not as good as one square foot in the fire-box, with anthracite coal. If that is true there must be something in radiant heat. I believe in this ether theory. I believe we can account for a number of things by accepting such a theory as that.

I also believe that radiant heat is exactly the same as light. Of course as a physicist I am very much of an amateur.

## XXXII.—Topic No. 5.

What is the relative value of the fire-box and flue surface in boilers?

Mr. Barron:—I should like to get Mr. Kent's opinion on this 12 square feet of fire-box. I want to get him on record on that question. Most engineers on fire-tube boilers or on water tube boilers fight shy of that question. We have a good opportunity here either to make Mr. Kent remain quiet or put him on record. I want to put him on record.

Mr. Kent:—I did not say that one foot of tube was as good as 12 feet of fire-box at all. Suppose you have a locomotive boiler having a fire-box in which one foot of surface is equal to 12 feet of tubes, according to Mr. Barron. If we have a fire on the grate we will get right above the fire a lot of gas, say at 2,000 degrees F. Gas at 2,000 degrees F. will send heat into the water above it at an extremely rapid rate, and as soon as some of the heat leaves it that gas is immediately cooler, and when it gets beyond the fire-box that same gas which was originally at 2,000 is only, say, at 1,500 degrees. When it gets a little farther it is only 1,000 degrees. When it gets to the chimney it is, say, 800 degrees in the locomotive boiler and 400 degrees in an ordinary tubular boiler. If you extend the locomotive boiler and double its length you will get at the end a temperature of only 400 degrees. But this extra tubular surface is of but little value, and this tubular surface in the front of the boiler, the same kind of surface exactly is worth twice as much as that in the rear, and the surface in the fire-box is worth still more, because it is exposed to hotter gases. We do not know whether the greater efficiency of the front of the boiler is due simply to the question of higher temperature of the gases or to radiation plus the higher temperature of the gases. It is found with bituminous coal in locomotive practice that if a fire-brick arch is built in the fire-box so as to shut off half of the radiation directly from the coal, although the crown sheet is protected from the direct radiation from the fire, the boiler will give better results. That is not due to protection from the radiation, but is due to another circumstance which is caused by that fire-brick arch, viz., the making of a hotter fire. So I say we do not know what the effect of direct radiation is. There can be no radiation directly from bituminous coal, because there is a mass of smoke and flame that prevents it. There may be radiation from the

white hot particles of carbon in the smoke right against the plate. So I do not know whether radiant heat or the high temperature of the gases is what does the work in the fire-box, and I do not think anybody else knows either.

## XXXII.—Topic No. 6.

Have the recent changes in the form of hot air furnace construction increased their efficiency?

Mr. Barron:—I think we discussed that fully yesterday.

The President:—I see Mr. Wilkinson here. We should be glad to hear from him on that topic.

Mr. Barron:—Well, I withdraw what I said. I did not know there were any gentlemen here who were interested. I want to hear the question discussed if there are.

Mr. Mott:—I do not know what the recent changes in construction are to which reference has been made. The only thing I can imagine it means is a reference to burning of gas, so-called, taking heated air into the combustion chamber, the fire having a high enough temperature to cause the ignition of those gases. That is nothing new. It was in use 30 years ago. I think it was agreed very thoroughly at that time that it was of no value as a heating agent.

Mr. Jellett:—When this question came before the board of managers there was some doubt in their minds on the question, and it was generally believed that the typical form of hot air furnace construction, what I would call the bar room stove enclosed in a chamber, was referred to. Since then a number of different shapes have been gotten up; some with horizontal flues and some with spiral flues. Whether with the change from the old form of corrugated stove to the more recent form—whether there has been a corresponding increase of efficiency—was the point I think in the mind of the man who sent the question. I do not know who sent the question.

Mr. Mott:—Taking it from that point there has been unquestionably a very much higher degree of efficiency attained under the more modern construction, and that efficiency has run in the direction of extracting the heat from the fuel instead of allowing it to escape to the chimney. All of the present constructions aim in that direction, and they have accomplished what they aimed at to a very large extent. There are some who claim to have gotten the thing down so fine that the smoke pipe is very much cooler than the pipes carrying the heat from the furnace. I looked upon that with a good deal of doubt.

Mr. Wilkinson:—I had not noticed this question particularly, Mr. President, until you read in it that form, and the question, to my mind, immediately was: What are the recent changes? I could not remember any particular recent changes in the method of hot air furnace construction. Mr. Jellett spoke of the old-fashioned stove put inside of a jacket, which has been in use for a good many years, but is now scarcely considered as a hot air furnace. The present constructions of hot air furnaces are arranged, as Mr. Mott has said, so that they do successfully extract a great proportion of the heat that formerly was wasted in the primitive form of which Mr. Jellett speaks. In regard to the different conditions under which we find the present method of heating by hot air, I might say that in the cheaper constructions of furnaces I do not think there has been any recent change that has increased their efficiency, but in the better grade of furnaces that are made, which are made for the purpose of installation in houses where a proper price is paid for installing them in proper form, I think we find very great economy. A gentleman said to me some time ago that the principle of heating by hot air is to have the hot air pipe hot and the smoke pipe cool, but I have never found yet any house in which I had a hot air furnace where the principle was carried out, for generally the smoke pipe is hot and the hot air pipes are cool. The present method of constructing furnaces aimed at by every furnace manufacturer is to reverse this, by having the air enter the room at as high a temperature as possible and having the products of combustion that pass into the chimney at as low a temperature as possible. This is to a certain extent accomplished in what I presume are the modern style of furnaces. The only object is simply to get the best results from the smallest amount of coal; the maximum results from the minimum amount of expenditure, of course. I might say, in reference to this, as a still further answer, that the arrangement of cold air inlets entering a furnace has a good deal to do with the efficiency of the furnace, which does not relate altogether to its construction; and the method of setting the boiler, the elevation of the pipes, the size of the outlets, the size of the registers, have a great deal to do with the efficiency of a furnace, without having anything to do with its construction in any new form, and I do not know any better way to answer this question than to say that the recent changes in the form of hot air construction have very materially added to the efficiency over the old form of hot air construction.

Mr. B. H. Carpenter:—I notice in some of the furnaces recently gotten out that the proportion between the radiating surface and the grate surface is a very much larger quantity than in those of some of

the furnaces that have been upon the market for some years. I should like to ask some of the gentlemen that are acquainted with the subject whether they have found the proper proportion for grate surface to radiating surface for the regular warm air furnaces?

Mr. Wilkinson:—I do not think the proper proportion has been found; we are reaching for it.

Mr. Switzer:—In regard to the construction of furnaces, after a close of observation and upwards of 20 years' practical experience, I can say that certainly there have been decided changes in the direction of improvement of the efficiency of hot air furnace construction by the various manufacturers and largely along the line of increasing the radiating surface, retarding the free circulation of the products of combustion through the chimney, retaining these products of combustion within the construction as long as possible to get the full benefit of the units of heat derived; also the increased capacity of the fire-box and the grate surfaces. In the older form of construction of furnaces, after the order of the cannon stove, so to speak, there was a direct circulation to the chimney, fire pots were largely very shallow, very flaring, being about 12 inches diameter at the bottom and about ten inches deep. The radiating surfaces were very compact, the air chamber being large, and the radiating surface became superheated. The efficiency of the more recent and modern furnace constructions has been along the line of extending the radiating surface, greatly increasing efficiency by increasing the grate surface, fire-pot capacity, increased radiation from the fire-pot inward and outward, largely increasing the radiating capacity, with a lesser consumption of fuel, which has certainly brought the standard of hot air heating to a higher level, and yet there is a great field for improvement. No doubt many manufacturers are all at sea in regard to the extent to which this development may be brought, and I will say, in passing, that while this was one of the most serious topics that was brought up I was in hope that there would be a good representation of members of the society who were fully competent that would bring data and information on which we would base some observations regarding their experience and take with us to our homes some positive information along the line of this inquiry. I did not come to make any extended remarks. I received a good deal of useful information on some other lines, but in this particular direction I was in hopes that there would be some positive data furnished at this meeting regarding the area, capacity of grates, fire-pot, square feet of radiation, and the amount of air circulated and the diameter of casing, that would enable us to arrive definitely at information that would be useful for the lifting of the standard of warm air heating.

## XXXII.—Topic No. 7.

What is the proper area for fresh air supply for direct-indirect and indirect heating?

Mr. Barron:—Mr. Jellett has proportioned a great deal of direct-indirect, I believe. Of course, it varies with different conditions. The rough rule of thumb ordinarily used is very loose. The methods laid down in such books as Prof. Carpenter's represent, I think, the average practice to-day.

Mr. Jellett:—I do not know that there is any definite rule on direct-indirect. If you make the air box as large as your radiator would handle it, the architect would object to your making the walls unsightly. I have put boxes 12 inches square, 144 square inches, and the radiator of 100 square feet of surface, and I have obtained excellent results. It is simply a question of fact. With a great many you will frequently find the air box ridiculously small compared with the radiators. The radiator manufacturers themselves are making a box that only fits a certain number of sections of the radiator. That is done to meet the conditions imposed by the architects, who do not want the walls made unsightly, on the theory that whatever air you get in is better than none. But you can actually handle much more air with a radiator than any form of box base I know of will provide for.

Mr. Barron:—My impression is that the use of direct-indirect is getting less all the time, or has been getting less, and there is less talk about it, and heating engineers pay less attention to it, because, while it is all right practically, there are always difficulties. About 12 years ago I was at Johnstown and I happened to go into the laboratory of the Cambria Iron Works, where the scientific men were making tests. The building was heated with direct-indirect radiation. All the inlets for air were shut off, on account of the draft. They annoyed these gentlemen. They would rather breathe impure air than have a cold draft occasionally. They were so highly organized that they could not stand that trouble. I happened to call at a school in Orange one day, which was heated with indirect radiation; I believe it was a very fine piece of work. I looked at the radiators and found the same state of things, and the teacher told me that that was customary—that they were always shut off. I know that in office buildings, in most places where you see direct-indirect the dampers are usually closed. I think it is an excellent way to heat a great many buildings, but the difficulty comes with practice. Of course, there is the objection Mr. Jellett speaks of that you cannot get the area for air inlets.

Mr. Quay:—There is another question in regard to proportioning. That is the velocity of the air. I find that, when the wind is blowing at a very high velocity, coming directly towards the opening, you get a great deal more air. You have to give a good deal of attention to regulate it in order to get proper results. It seems to me that some of our scientific men might get up a regulator to regulate dampers of this kind by the velocities of the air.

Mr. Jellett:—One thing I would add. From what the gentlemen have just said, I take it that they are in the habit of using direct-indirect with cold air boxes back of any form of radiator. I never do that. I put my cold air box directly at my window and carry the sheet iron flue down. It is impossible to have the air blow through the radiator that way. I never use the direct-indirect system with an open radiator, or with a pipe coil, because you would be subject to those drafts at any time. I believe that the direct-indirect system belongs to the type of radiator in which you can direct the air through its flues.

Mr. Barron:—This radiation that I speak of at Johnstown was a horizontal coil enclosed in a casing.

Mr. Quay:—A question which has come up recently in regard to this, in a city where they use soft coal and have a great deal of soot and smoke, has been as to whether there is sufficient objection to the direct-indirect on account of the amount of smoke brought into the room through this opening.

Mr. McKiever:—I want to say, in relation to the draft spoken of as coming through these radiators, I know that in this city, where they were first applied to our public school buildings, the objection spoken of was found, and, in order to offset the difficulty, they put in a corrugation which formed the flues of the radiators when the sections came together.

Mr. Wilkinson:—I should like to ask whether the direct-indirect system of steam radiator is used to better advantage than the direct-indirect system of hot water radiators. I have in mind a building in which there were a number of direct-indirect hot water radiators placed, and they could not seem to get any benefit from them whatever, and so they shut off the direct-indirect entirely and have left the opening closed. In another building that I know of steam was used, and they had very good results. I should like to ask what is the opinion of others in reference to the use of direct-indirect with hot water radiators. I have used them in the form Mr. Barron has spoken of and closed them in, because there was a draft. I never used them with the base that has been spoken of.

Mr. Connolly:—I would say that direct-indirect hot water radiation

has been used, but always with automatic control, the Johnson system. Of course, that does away with freezing.

The Chairman:—Unless there was some automatic control I think it would be a very difficult thing to successfully use hot water.

Mr. Wilkinson:—I should judge that would answer very well.

## XXXII.—Topic No. 8.

Is the present form of disk fan and blower construction the best that can be devised?

Mr. Quay:—I move that we pass that, as we have had it discussed this afternoon.

## XXXII.—Topic No. 9.

Is there a satsfactory combination or interchangeable system by which buildings may be cooled or warmed at pleasure?

Mr. Connolly:—I think this is one of the most important questions that has come up, and I should like to hear it discussed thoroughly. I do know that on a fan system, with hot water or steam, an auditorium of a church can be cooled with the fan revolving, when all of the pipes, radiators, etc., in the indirect part are full of water, and a reduction of ten degrees can be effected.

Mr. Stangland:—I think this resolves itself into a question of dollars. You can do anything with dollars—cool a church or warm it. There is no engineer within these walls to-day but could cool a church or heat it if he was paid for it, by steam, or hot water, or furnace. It is a question of dollars.

The Chairman:—The question is, Is there a satisfactory combination? The word combination implies that the same system shall automatically handle all parts of the building. Now, it may be necessary to warm a certain section of the building, and at the same time another section may not require any heat. I take it this question has more in it than is on the surface of it.

Mr. Barwick:—I think Mr. Crosby can give us some light in regard to the subject. I believe Prof. Woodbridge put in a blower system at a theater in Boston and also arranged the same coil to circulate cold water during the summer time; that is, ice water. Whether it was successful or not I do not know, but possibly he can enlighten us.

Mr. Crosby:—As I understand the question, it was a combination system that could be shifted at will and at very short order. If that is so, then I do not think this system to which Mr. Barwick refers hardly applies. I think he has reference to a theater in which the coils were changed from the original form put in by the blower com-

pany and so piped and cross-connected that in summer time cold water, or brine, if necessary, could be pumped through them, and in the summer season the system could be used for cooling the theater, the same coils being used for steam in cold weather. So that, while it was one and the same system, yet it could be used under different circumstances and at different times. But there was no arrangement, except possibly by-passing and automatic control on one or more sections that would temper the air during the time they were running the system with steam.

Mr. McKiever:—I have in mind a system designed for a very large clubhouse in New York, in which they set out to accomplish the same results, and after the system was put in they discovered that they did not need any cooling, because the clubhouse was practically closed in the warm season, as the members were all absent. I think there is more in this question than has been brought to light. I think that the moisture of the air is a very large factor in the case, and I think that any great degree of cooling would be felt in the summer, as refrigeration is felt in any building that is especially designed for that purpose.

Mr. Barron:—I think that this is the greatest question that has come before this meeting. But the interpretation, given by yourself and others to the question, I think, is not the right one. The interpretation I will put on it is this: Is there a satisfactory system that you can apply to the building by which you can heat the building in winter time and cool it in summer time, with the same system, with slight modification. That has been done for years and years, not in this climate, but in the climate of England. There, in the houses of Parliament, I understand, in summer time they want the windows and doors closed for the purpose of securing good acoustics, and I believe there is an objectionable fog there occasionally. They use the same apparatus I spoke of yesterday, that blows the air over the hot furnace for heating. They use the same blower or fan to take air over ice. That is, the air is passed over ice, just as it would be passed through a cold blast coil, and delivered into the houses of Parliament while members are in session. That is my understanding of the description given in Dr. Billings' book. It probably has been done in other places, but that is the beginning of the system that I think will soon be in use in all climates such as ours, because I think it is a very desirable thing that the same apparatus should be used for cooling and heating. We are ventilating engineers, that means cooling engineers. Of course, that is not the essence of it, but that is the way a person feels. Mr. Stangland, I think, has had as much experience as anybody here. I should

like to have him tell what he knows has been done. I know of hot cellars, in which it was impossible to do any business at all, and by putting in a fan they could keep those places very comfortable indeed, the atmosphere being made quite agreeable on a warm day, and they use nothing except a change of air, bringing the air down into the cellar and then discharging it.

Mr. Stangland:—Mr. Barron is right in saying that I have had some experience in that line, but always in the line of failures. Dollars was the question. There is no small theater of recent construction in this town, but what has had provision made for cooling. You see the large pass-by from the air duct into a chamber 10 by 15 by 20, with racks for ice. They will hang out their gorgeous posters saying: "This theater is cooled by ice." The question of keeping that audience from four or six degrees cooler comes up. That means 25 tons of ice, as a rule. There they fall down. You find that they will put in about 600 or 700 pounds of ice in the rack, and they will take the air from the theater if they can, and turn it over and over until they have reduced the temperature of the room when you enter about 10 or 15 degrees, with the doors closed. That is the end of it. The ice is gone and the play is going on and you forget that you are being roasted. Some of the later hotels have put in such circulating coils. I have in mind one in the New Netherland—a large chamber and coil for heating and with connections for brine for cooling the billiard and pool alley for summer. It never has been run. Why? Dollars. I have in mind that, a few years ago, when roller skating was just about petering out, the problem was to keep the place at 10 or 15, perhaps 20, degrees. Some of the members may know of the old Durland Riding Academy, in which it was desired to reduce the temperature of this room 20 degrees. Mr. G. A. Suter had the problem in charge and it resolved itself into the ice machine. But to cool the building would have cost $80,000. You can guess whether they fell down or not. In each case it has resolved itself into the question of dollars. People will not pay for it. Mr. Adams gave me a very interesting little sketch of the cooling of his place. Those who have been at Washington, perhaps, may know the place where Mr. Adams' drawing room is located, and all his men are working in an exceedingly warm place. He put in a sort of tempering blast by which he thought he could bring the temperature of his room down so it would be comfortable for the men to work in. He put in three tons of ice and by evening he shut down the apparatus, because all the papers on the drawing boards had curled up and they had to put weights and some boys on them to hold them down. So the question of moisture came in. The question I should like to have settled

is why there is an excess of moisture in the air after it has passed the ice? My belief is that the air should be drier. Mr. Adams, nevertheless, says that every paper on his board curled up, and that there was an excess of moisture. I have believed always that moisture would deposit on the ice and the air would be dry. So it would seem, if what Mr. Adams says is true, that we must use pipes in which there is brine.

Mr. Barron:—I believe that the architects who design buildings like the new Waldorf Hotel, if it was generally understood that this thing could be done successfully, would consider it, and I have no doubt it can be done, and it is merely a matter now of the opinion of the men who require such things. A hotel is used all the year round and it should be a little more comfortable in it than outside. It is probably a very difficult problem to handle, but I believe it would pay in hotels to have them cooled in summer time, and I believe it is our duty to say, as ventilating engineers, that we can cool a building if people want to pay for it, but that it is exceedingly expensive. It costs a pile of money, but if you want it it can be done. It is merely a matter of ingenuity. A great deal of work in that direction has been done and done successfully. I should judge that the various ventilating houses, such as the firm Mr. Stangland is with, have such data and experience that they could handle work of that character and guarantee its success. Of course they would have to state that the cost of running such plants would be expensive. But we pay excessively for electric light and all these improvements.

Mr. Crosby:—In regard to this theater that was arranged to be cooled in summer, I believe the same reluctance was found on the part of the management that the gentleman on my left has referred to in regard to the quantity of ice. He was very much horrified when he found it required something like 20 or 25 tons of ice, and I think the first evening the theater was in use he put in something like six tons of ice to cool his auditorium for the whole evening. This is only what I have heard. But I understand that they have run that cooling system about half a dozen times throughout the whole half season, or half summer. At the present time there is being installed, as part of the new system of ventilating and heating—I might say cooling in this case—in the United States Senate, in Washington, a small refrigerating machine. I believe they were rather limited in the size by the amount of the appropriation that was left after installing the heating plant. The original intention was not to install the refrigerating plant, but having some money left they put it in that form. In that case the main heating coils are cross-piped, so as to circulate brine in hot weather. In that case it would hardly be a question of tons of ice purchased.

Mr. Stangland:—It has been a sort of pet idea of mine that I might come across some theater or hotel that would adopt an idea that seemed to me rather economical from the standpoint of dollars. Many of the hotels to-day are putting down artesian wells. We know that, as a rule, the water comes from them at a temperature of 54 to 56 degrees. If we could reduce the temperature in the rooms by coils in which we could pass that water on its way to its use (they rarely use it for any purpose for which they care to have it at 54 degrees), taking about ten degrees temperature out of that water, the drying effect on the air of removing moisture through the agency of the coils would be especially beneficial, and, as one of the speakers has mentioned, the very fact of getting moisture out of the air and delivering in the rooms in which we live would be a decided improvement over the ice principle, which, if it does bring in moisture, is objectionable. And I hope at some time to find some man who will have nerve enough to put in a coil and pass water from the artesian well through it (its usefulness is not thereby impaired at all), and so get some data as to what can be done with the artesian water.

Mr. Inglis:—I can refer the gentleman, I think, to a plan which has been in operation for some five years on almost those same lines. I refer to the Metropolitan Opera House in St. Paul. They have in use there a fan system of heating, with the usual coils, etc., and the owners of the building (I think without consulting the heating contractors), it being in the summer time, when all were sufferng from the heat, having available an artesian well, the temperature of the water of which was 52 degrees, without any expense whatever, turned the water into the coils. I do not know whether any critical tests were ever made, but they said they succeeded in reducing the temperature very materially, so much so that in very warm weather the people would come to the theater to be cooled, instead of staying away from it for fear of being roasted. So far as I know that plan is in operation to-day—well, not to-day, because I presume it is 20 degrees below zero out there—but it is in use to-day for heating, and I presume that next summer it will be in use for cooling in the way described.

Mr. Mott:—Some two years ago, while in Pittsburg, the Carnegie office building was being erected. I heard, when the building was being rented, that the rooms were to be at 70 degrees winter and summer. I went around to see it and found that it had a regular system of direct steam heating throughout the building. They had artesian well water, in the neighborhood of 50 degrees, and their idea of cooling in summer was to attach the steam pipe system to this well and pump the water through the system. Well, I was satisfied

as to how it was going to work. I called next summer and found they had cancelled all the contracts. I believe that the condensation on the radiators was such that it very nearly washed them away. I would also state that I came across a case very recently where a party was a grower of a certain material that required a low temperature, and he attempted to use the fan blast, going over ice. The money question did not come into the problem, as he was perfectly willing to pay for his ice. But the moisture arising from the ice killed his product.

Mr. Barron:—These proceedings of ours will probably be read in places where they do not have the same conditions we have in this city particularly. What we suffer from here in summer is not temperature so much as excessive humidity. That is the difficulty here. And if, as Mr. Stangland suggests, we can bring that humidity down to a percentage that is comfortable, the other parts of the cooling problem are not of such importance. That is the great trouble in New York—excessive humidity in summer time.

## XXXII.—Topic No. 10.

Is there a simple, practical method of controlling the amount of heat desired in heating by ordinary radiation?

Mr. Barron:—In order to start that subject I would say that Mr. Tudor's fractional valve is simple; I do not know how far it is practical, never having tried it. I think it would be all right, but for some reason or other the public do not seem to want it, or Mr. Tudor does not seem to care to force it on the public. But that was an attempt in the direction of regulating steam equally, outside of the ordinary thermostatic regulation.

Mr. Connolly:—Is that the only method of which you are aware?

Mr. Barron:—I will allow Mr. Connolly to give all the other methods.

Mr. Connolly:—The only one of which I know that is successful is this: Take an 11-section radiator and put an automatic air valve on the fifth or sixth section and a positive air cock on the end where the automatic air valve should be, and you can use one half of the radiator by closing the automatic air valve, and opening the air cock, of course, will give you the benefit of the whole radiator.

The Chairman:—On the principle of air cushioning, you mean?

Mr. Connolly:—Yes. That is all it is.

Mr. McKiever:—There is still another method practiced in this city. It was done in the Mutual Life building by dividing the radiator off into sections and putting controlling valves in each section.

Mr. Connolly:—I have an automatic air valve on the end of an 11-section radiator in my apartments. After I get four or five sections warm I simply close the air valve. It may run over one section, but never over more.

Mr. Barwick:—I understand from Mr. Connolly that it is a one-pipe job, is it not?

Mr. Connolly:—Yes.

## XXXII.—Topic No. 11.

Is there a simple and correct method of determining the extent of vitiation of air?

No discussion.

## XXXII.—Topic No. 12.

What is the cause and preventive of the corrosion of steam pipes when packed in mineral wool and placed under ground?

Mr. Barron:—Mr. Kent has left a discussion here as follows: "Sulphur in the mineral wool, probably in the form of sulphide of calcium and sulphide of iron. Moisture with heat acts on this, and sulphuric acid may be formed. Remedy: Don't use mineral wool in places where moisture can get to it. This subject was discussed in the transactions of the American Society of Mechanical Engineers about ten years ago."

I will say I have had occasion to use it a great many times where moisture could get to it, and the reason I used it was because I did not know a good substitute for mineral wool. We know it has faults, as we know the faults of a good many things, but we do not know where to find a substitute with the necessary virtues.

## XXXII.—Topic No. 13.

What is the most efficient form of fire-box for burning bituminous coal?

No discussion.

## XXXII.—Topic No. 14.

What is the relative value of fan blowers of large diameter run at slow speed and those of smaller diameter run at high speed?

No discussion.

## XXXII—Topic No. 15.

What is the maximum velocity at which air may be introduced into rooms without producing noticeable drafts?

Mr. Jellett:—This is a pretty hard question to answer satisfactorily. It depends altogether on the size and shape of your room. I usually figure on a velocity not to exceed 400 feet at the register, if the registers are placed on the side wall or in the floor.

I am constructing a system of heating for the operating theater in a hospital, where I am keeping down to 200 feet, because the heat must be reduced under the seats. The air comes in and is shot down to and spread on the floor. It is done with the idea of preventing unpleasant drafts. The 400 feet velocity is about as much as I want to give on the average side wall register, unless it is above the heads of the people entirely. There it will stand a little more than that.

Mr. Crosby:—I know of a number of cases in school rooms, where the bottom of the inlet register is at least $7\frac{1}{2}$ feet from the floor, the air entering the room at as high as 800 feet velocity. But in such cases diffusers are used and the air can be sent at a higher velocity and be distributed better about the room. By using diffusers not so much care was required in the placing of the inlet registers, for by varying the form of the diffusers and entering the air at that high velocity it can be distributed to different parts of the room better than at a lower velocity.

Mr. Barron:—I would ask the chairman if 300 feet is not about the average, from his experience, and if that is not about the minimum, and if it is not a fact that the diffuser is really the only practical solution of the question. That is, as time goes on, we will get to higher velocities, and the use of the diffuser or something of that character is the solution of the difficulty, which always confronts the man who goes to designing an inlet for air into a room.

The Chairman:—I think there is a good deal in what Mr. Barron says.

Mr. Stangland:—I should like to ask Mr. Crosby if he can give us a little sketch on the board of his idea of a diffuser, or such as he has seen used. It is an interesting problem as to the distribution of air in a small room—an ordinary school room accommodating 50 scholars, 21 by 14 feet, and it would seem as if it was almost impossible to get the architects to raise the inlet registers beyond seven or $7\frac{1}{2}$ feet. Why not go to the ceiling at once? That is the place which the air, if it is warm, seeks; it goes to the ceiling if your register is at the floor. Now, if it is started into the room at seven feet and is objectionable, haven't we a remedy in going to the ceiling? If the air

is exceedingly warm, that is the place to which it immediately goes. If the air is cool, then it goes downward. It seems to me that the inlet for air, whether cool or warm, should be at the ceiling. If it is cool, there is all the more reason why it should be at the ceiling. It would help to solve the question of velocity, as we are often restricted to a narrow duct.

Mr. Crosby:—I can show the general form. A sectional plan view of the diffuser would look something like Fig. 53, being constructed

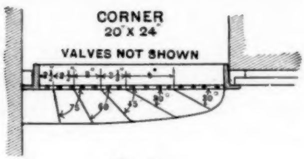



Fig. 52.

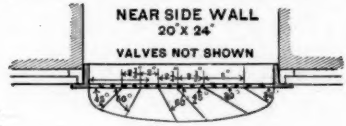



Fig. 55.

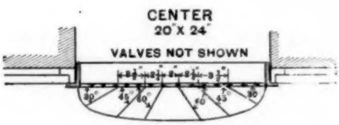
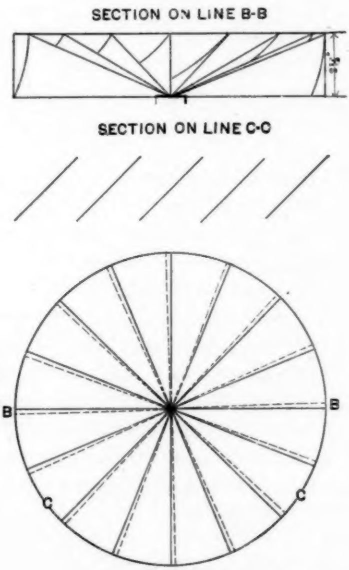



Fig. 53.



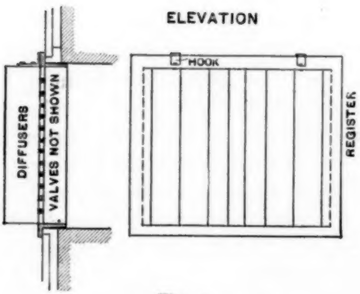




Fig. 54.

Fig. 56.

of two vertical sheets of metal, a top and bottom, as indicated in Fig. 54, between which are vertical vanes, placed at varying angles. From the center there are two vanes that are set with wide angles. The next ones on either side are at sharper angles with the wall plate, the third ones coming out very sharply. With this diffuser, instead of the whole volume of air being shot directly out into the room, to perhaps cross it and strike against the opposite wall and pass downward, as we sometimes find it under those conditions where

there is a high velocity, it will be so broken up and diffused over the whole room that drafts will not be perceptible. Of course, the form of diffuser shown in Figs. 53 and 54 is only to be used where the register opening is in a central position in the room. But in case a fresh air opening came in the corner of the room you would change the form of the diffuser, as indicated in Fig. 52, and so adapt it to the position of the register. Other forms of the diffuser are shown in Figs. 55 and 56, the latter being a circular diffuser.

Mr. Barron:—It seems to me that, if you threw the register away and used only the register frame, it would be better. A flat plate would be a better arrangement, moving out and in, and that would act as a perfect diffuser and also regulate the volume of air. A mechanism could be readily arranged to work the plate, being graduated to any opening you like, and that would diffuse in all directions. The objection I see to it is the downward diffusion. If it diffused as the other ventilator does, upwards and sideways only, I think it would be the coming register. The present register is objectionable, although perfect for hot air furnaces, under old conditions. The coming register will be a diffusion register, to meet this question of velocities; because I believe the plenum system man, the hot blast blower man, who says, "I want no ventilator flues at all; give me air anywhere and I will heat and ventilate your room," with the proper engineering applied to his bullheaded theory, is the coming man. That inlet is the germ of the principle that is to be the successful principle, and that, of course, means small flues and high velocities. The small flues will certainly take with the architects. I would not be at all surprised if we should have, for both ventilating flues and forcing flues, a 2-inch pipe to heat a room as large as this. Those are just the crude theories, in my mind, of what is coming. Take a building like the St. Paul. You could not afford to ventilate it in any way, except by a 2-inch pipe for an office. Of course, the velocities will have to be high. But it would be better ventilated than it is to-day, as at present there is no ventilation at all, except by the windows. If a man keeps the window down all the time people will be getting cold from the draft. High velocity will get us out of that and you must meet practical conditions. We cannot make every art to bend to us. We must adapt ourselves to all the arts.

Mr. Quay:—One of the leading architects, about three years ago, stated to me that he thought some engineer ought to devise a plan for heating buildings through radiators by hot air. He said his idea was that the pipes might have to be larger, but thought that might be accomplished some time. He wanted me to take it up and make

him a report. I took it up in my mind and investigated everything that I had an opportunity to, and I stayed away from him for about two years lest he should want to get my report. I met him this last year and he broached the question again. I told him I would bring it before our society some time to see if any person had more light on that subject than I had. He still has that idea. I have not faith enough in it yet to know whether it can be accomplished or not. We do not know what might happen. Wonderful developments are being made in these times.

Mr. Stangland:—I should like to ask some of the members if they have ever tried or have seen tried a form of register that might possibly do away with the inequality of flow which we all meet. We all know that, as a rule, the valves and registers open on a vertical plane, but it is not possible to make those valves horizontal, instead of vertical, using first a 4-inch, or a 3-inch valve, the next one projecting into a flue a certain distance further than the next one? Perhaps there might be three or four of those valves, leaving the other ones to be of the usual short form. Would not that arrangement tend to break up that blow of the air of about one-half of the register face, making the valves of similar material to the present, but making either two or three of them of an extended length?

Mr. B. H. Carpenter:—Instead of using a regular register face, we have recently used a wire screen face, not very ornamental, but they give a larger area and work very nicely, and we have used the deflectors as described by Mr. Crosby a few minutes ago. But in one case we had a room which was long and narrow, three sides of the room were exposed, and one of the long sides was the inside, and the one in which we ran the flue up. The room was so narrow that even by using the deflectors there was still a draft, so we took them off and used a deflector of sheet iron that threw the air all up to the ceiling, probably ran up nearly two-thirds of the height of the register, and that threw all the air to the ceiling and divided it very nicely, and we had no further complaint. The register was about eight feet from the floor, the room was about 12 feet high, and the teacher in that room told me, a few weeks ago, that it seemed to be the same in all parts of the room, and that there were no drafts.

The President:—Did you mention the size of the room?

Mr. Carpenter:—No, I cannot. The room had about 9,000 cubic feet of air space.

Mr. Stangland:—We have wandered somewhat from the question. I brought up the question, should any one try another form of valve, with a view of avoiding half of the register becoming an outflow and the rest of it an inflow, due to the injector principle?

Mr. Crosby:—I do not know that I can say anything in answer to your question, but in one school where, for particular reasons, I took a reading at each opening (of which there were seven) in the diffuser at three different levels, making 21 readings, the register being 24 by 30 inches, the average readings on the lower level, that level being just high enough above the bottom of the register face, so that the full ring of the anemometer would just clear the frame of the register face, were almost the same as the average readings at a point a trifle above the center of the register.

Mr. Stangland:—Do you recall the speed at which the air entered?

Mr. Crosby:—Well, there was one reading at the top level as high as 500 and it dropped as low as 400 at the bottom. Of course, the readings had to be taken some four inches in front of the register face at first, because of the diffusion, the openings not being large enough to insert the anemometer clear in.

## XXXII.—Topic No. 16.

What is the relative efficiency of one air outlet compared with four or five smaller outlets in different parts of the room?

No discussion.

## XXXII.—Topic No. 17.

Is not a mixture of coke an anthracite coal cheaper than and as satisfactory as anthracite alone?

No discussion.

## XXXII.—Topic No. 18.

Which is the better, to place the thermostat on the inside or outside walls?

No disucssion.

## XXXII.—Topic No. 19.

How many feet of direct water heating surface can be supplied with heat from one square foot of water heating surface in a combination hot air and hot water heater?

Mr. Wilson:—This is a question which cannot be answered definitely, as it is largely determined by the conformation of the water section or sections, their distance from the fire, whether water surface is above the fire, or in the shape of a water ring on the firepot, or a

combination of both. The above conditions are, in my experience, sufficient to produce varied results. There is yet another condition which is often overlooked in apportioning heating surface, and that is the length and elevation of the warm air pipes. I believe the arrangement of the warm air portion in a combination determines the efficiency of the water heating system, even when a normal rating of the value of the water surface in the furnace has been obtained. We are admonished by the manufacturers, in their catalogues, to so place the combination that the warm air pipes will be short and of equal length. Those who install such systems know that in a majority of cases such a location is not obtainable, as the apportionment of the water and warm air to the different rooms to be heated is very often determined by the wishes or whims of patrons. This often results in the installation of long horizontal runs of warm air pipe to rooms distant from the apparatus, requiring increased firing in the furnace to obtain satisfactory results. This high temperature in the combustion chamber and the absorption by the water surfaces of a large number of heat units cause a wasteful overflow of water from the expansion tank. I have heard of more complaints on this score than from any other cause. When the water surfaces are of such a shape that they can be covered with some non-conducting fire-proof material this evil can be mitigated. Water surface or coil construction can, where the mains are short and radiation not too much divided, be rated at one square foot of water surface to 30 square feet of radiation. Where the mains are long and the radiation is divided into a number of small radiators, the average will be one square foot of water surface to 25 square feet of radiation. This is for direct radiation, with covered mains, temperature of water 190 degrees, outside temperature zero, temperature of room 70 degrees. The numerous cast combinations which form part of the firepot and have suspended surface above the fire will rate somewhat higher. I have had such constructions to rate as high as one square foot of water surface to 50 square feet of radiation where favorable conditions existed. It seems to me that manufacturers of such goods should give an approximate rating to their combination as follows: First, to give amount of radiation water surface will heat; second, amount of warm air such apparatus will furnish per hour in conjunction with the water surface; third, the temperature required for the air and water to perform such work to heat a given space to 70 degrees when outside temperature is at zero. With such data the contractor would be enabled to install a satisfactory heating plant. The ratings as usually given in the catalogues of the manufacturer are conflicting and misleading.

## XXXII—Topic No. 20.

How can the humidity in buildings be regulated?

No discussion.

## XXXII—Topic No. 21.

What should be the velocity of flow of the steam in the pipes of a low pressure steam heating system?

Mr. Quay:—On the topic about the velocity of steam I do not know that we have much data—I have not much. The amount of radiation that a certain size main will supply depends to a certain extent upon the velocity of the steam flowing through the main, and in deciding what size mains and branches we should use to supply radiation, the question of velocity is one that ought to be considered.

Mr. Barron:—I would suggest that Mr. Quay prepare a paper for our next meeting on that subject, because it is one on which we would have to look up data, and then that would start a discussion which would bring out all the facts.

Mr. Kent:—I heard a discussion on this subject last night by Prof. Carpenter at the dinner table, and it was very interesting. I am sorry he is not here to give us some points on it.

Mr. Quay:—It might be well to pass that topic then.

## XXXII.—Topic No. 22.

"What should be the relative sizes of the steam and return risers in a two-pipe low pressure steam system?

Mr. Barron:—We discussed that at the last meeting or the one before. It was discussed by Mr. Baldwin and a great many of the members here, and Mr. Jellett gave some very excellent proportions —what they use in their Philadelphia practice. I believe Mr. Wolfe has also written something on the subject of relative size of steam and return risers. I proposed the question originally. My contention was that the return—surely an empirical way of looking at it— should be one-half of the size of the steam riser, instead of the usual practice here in the East, on a double pipe system, of making the returns just one size smaller than the supply riser. Now Mr. Baldwin immediately assumed that we were referring to very low pressure, I think, and his discussions simply bore on that part of the subject. But what I refer to now generally are of course reduced pressure systems, such as we use in our large buildings. Mr. Baldwin particularly referred in his remarks to the gravity return system;

whereas the discussion was really in reference to a return system with a pump. That is not a gravity system.

Mr. Quay:—To two jobs in particular my attention has been called; one that was planned by one of our leading heating engineers, in which the return riser was just one size smaller than the steam riser, a three and a half inch steam supply and a three inch return. Now it seems to me that for economy we want to condense all the steam in the radiator. We also know that when steam is condensed the amount of water is very small, and it seems to me not only unnecessary to use a return pipe so large, but it is not economy either in first cost or in operation, and I am surprised that gentlemen who stand in the lead as heating engineers to-day specify these sizes and insist on their use after having their attention called to all these facts. Then some of them go so far as to say that nothing but a two-pipe system will work, and the same men will say that a one-pipe system will not work. I think some of these heating engineers need to be straightened out a little. There is another danger in making the returns too small. I do not believe that you can take the condensation from a radiator, and all of the sediment, sand, and dirt that accumulates in a radiator through an aperture of a hundredth part of an inch, without having to look after it a good deal.

Mr. Barron:—Mr. President, I have nothing to say except that I indorse everything Mr. Quay says.

Mr. Jellett:—I discussed this question some two years ago, and I am following the same practice that I followed then, although I have figured it out in a number of different directions more completely than I had at the time I last spoke. I always use a rule of proporing the area of the steam pipe to the amount of radiating surface that is being served by that steam pipe. I also proportion the return pipes from a radiator of any number of radiators by another rule, of the areas due to the amount of condensation to be carried, from the condensation of the steam delivered. For example, we have found that, taking one pound steam pressure as the basis for, we will assume, a large building where exhaust steam is being used and live steam through a reducing valve to supplement an insufficient exhaust, we start with one main pipe; we take a fraction of a thousandth of a square inch of area in the main pipe to the amount of surface served. Assume a building that is 350 to 400 feet long, eight or nine stories high, and possibly 150 feet wide, the boilers being located in one corner of it and with your heating pipe mains necessarily starting from that point. I have in mind a system that is somewhat on the lines I have described, only the building is larger. We go to the attic first with our mains. I take the total amount of surface in that

building and I allow in that main pipe five one-thousandths of a square inch of area to each square foot of radiating surface served. The particular case I refer to has nearly 50,000 feet of surface in the radiators, outside of some aspiring coils, etc. The heating pipe is 18 inches where it starts, but the return pipe is a five inch pipe after all the others are brought into it. Where we branch in the attic from this main pipe, we take the side branches and have nine one-thousandths of a square inch of area to the surface served on those lines. We then drop through the building and take side lines of the radiators. The radiator connections are twelve one-thousandths, because the friction is greater through a small pipe; so we use twelve one-thousandths. The drainage connections from the radiator are three one-thousandths, but the drainage in the basement is only one one-thousandth. So it starts with five, on account of larger areas and little friction, increases to nine, due to the additional friction on side lines, goes to twelve one-thousandths into radiators, three one-thousandths out of them, and down to one one-thousandth, when you get on the main return. Now that will not only carry the water but it will also carry with it the vapor and it will carry with it air. I have put up such systems as I have described and never used an air valve on the radiator. I have used the clearance between the water and the area of the return pipe as the vapor pipe for the whole system, and I tap that pipe back of my return traps and put a breathing pipe to the atmosphere. In the morning when the system is started up, assuming that the heat is entirely shut off the night before, I open the gate valve on the breathing pipe.

The air is all brought to that point and out through this vapor pipe. As soon as the system is heated up the valve is throttled down, and it becomes the air valve for the whole building. I have buildings with that system where I have as many as 550 radiators, and I never found a use for an air valve, except where I come up to hallway radiators, and I could not get to my radiator on the down line, I used an air valve to induce the steam to come to that point by creating a partial vacuum. On direct heating, the proportions vary according to the conditions to be met. Condensation is very much more rapid, of course, with a fan system. I have used a rule there of 21 one-thousandths in immediate connection to the fan heaters and never had any trouble in supplying them with steam. Of course, if the weather goes 30 degrees below zero, that area would have to be increased. On the returns from fans I have always allowed very liberal clearance, because if there is any dragging, there is a tendency to freeze, due to the amount of cold air driven in contact with the return pipes, and I have used there, instead

of three-thousandths, an area of nine, and in one or two cases as much as twelve one-thousandths on the return from the fan heater. But I never think of using less than a three-quarter inch pipe on any system, because I found all sorts of obstructions in the small pipes. In using half-inch pipes they are usually easily bent out of shape. People will put their shoes on them if they are horizontal mains, and if they are vertical, they will push desks against them, and the difference in cost is almost infinitesimal; so that I have always used three-quarter inch pipes as a minimum. Taking a system of that kind you can get entirely satisfactory results. In making specifications I have limited the contractors to two pounds pressure; but under average conditions the system should never exceed one pound pressure. I know of one building where it has been in use seven years. I have never seen one pound registered on the gauge. Generally you find that the pin of the gauge is off the point. It is a very large diameter gauge, so that any movement of the pointer would be indicated. That building will heat thoroughly and circulate at half a pound pressure at any time. So I am satisfied that I am getting area enough to supply the radiators with a sufficient amount of steam and also to clear them from water, and that I am using the minimum sizes of pipe that can be used to advantage—unless there is some method on the other end of the line to either mechanically extract air or water; I am not doing either.

Mr. Barwick:—You say that the air is carried through the same return pipe and passed from the vapor tank to the roof?

Mr. Jellett:—It does not enter the tank; no.

Mr. Barwick:—Well, it is carried from the return to the roof?

Mr. Jellett:—Yes.

Mr. Barwick:—Allowing the air and vapor to pass from there?

Mr. Jellett:—Yes.

Mr. Barwick:—Then, according to that your returns must be carried dry?

Mr. Jellett:—They are. On that sort of work I never use sealed returns.

Mr. Barron:—Couldn't you carry the return on the ground?

Mr. Jellett:—No. There would be no room for the air. Then in any system of that kind I believe in getting the water back to the main receiving tank as hot as I can get it.

Mr. Barron:—In New York you would have to seal it.

Mr. B. H. Carpenter:—Do you use those lines on boiler work where the water returns from gravity?

Mr. Jellett:—Not the same proportions, but I use the same form of rule. I cannot return the air to the boiler. I want somebody to attend to the boiler. I do not want any air valves on the boiler.

## XXXII.—Topic No. 23.

What is the best method of connecting the steam pipe to a power header and from the header to engines and pumps?

Mr. Jellett:—That is a good question for discussion. I have followed several ways of connecting up steam pipes. They are not all right; that is sure. I don't know how you can discuss this question without sketching. I will go to the board. We will assume, for the sake of the discussion, a tubular boiler having a connection coming from A, instead of the dome (referring to Fig. 57.) Where I have had a battery of boilers together I have frequently put in cast iron chairs (see Fig. 57), with rollers carried on the side walls of the

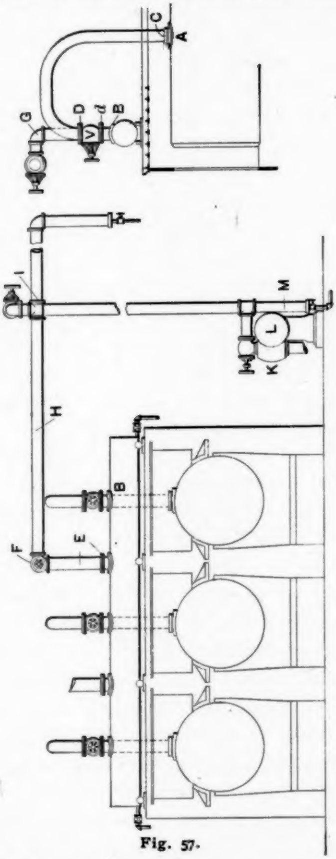


Fig. 57.

boiler settings. Connection with the header or manifold was made at B, with my valve looking out. On large areas I would use by-pass valves. The connections are sometimes made of copper, sometimes of wrought iron. There is a flange connection at C, one at B and others at D and d. The manifold running lengthwise is free to come and go on the rollers. I put up large batteries of boilers, 10 and 12 boilers in a line, in that way, using cast flange fittings, and have had no trouble whatever with leaks. Now, we will take the face view of the manifold itself. The steam is delivered into the top. From each end of the manifold I carry a drip pipe to drain it. I return the water of condensation. We will have a connection at E going off to supply an engine. Generally there is a valve at F. At G I have used a screwed fitting. We will assume we are running a number of independent lines from the manifold. There is generally no trouble in running one line. But I do not think it is good practice to run a large modern plant from one connection on the manifold. There is a freedom of movement here at once. Extend line H anywhere you please; it may have connections taken off it at a number of different points, but they are all taken off at the top. This main is relieved at the end of the pipe line again. I am speaking without any reference to separators. At the point I we will take off the various connections that go to the different engines. I will assume that the owner cannot afford to put a separator on the engine. I will take my line from the point I and drop down opposite my engine. The steam chest, we will say, will be represented by K, and the cylinder by L. Usually the connections are carried down to a point practically between the steam chest and cylinder. Now come out and run down to the floor and relieve again as at M. I do that with every main line that leaves my boiler manifold. It means a certain number of feet of small pipe connections, but I have yet to see a system put up in that way where I cannot take the water of condensation in the manifold and the pipes themselves and keep it from passing through the cylinders of the engines and pumps, and, in addition to that, you can generally get the dryest possible steam. I am absolutely free on expansion, and in case of a flooding or a syphoning, I have the areas of all these pipes of the entire system to free the water at once. That will do more than a separator will do, unless you have an enormous one, because I have the sum of the carrying capacity of all the drip pipes, and all these drip pipes do not cost as much as a couple of separators. I had a case a short time ago where a new fireman, not familiar with the battery of boilers that we had in use, started up his pump and went off to do something else and flooded his boilers. An-

other fireman came along, saw the pump running, thought it was time to shut it down, did not pay any attention to the boiler, shut this pump down, and he looked up at the water glass, thought that the water had gone down, although the glass was entirely filled, opened up an engine, and all of a sudden a slug of water came along as he added about 80 horse power. It made a rush of steam there. It simply filled all those pipes, but there was no engine wrecked at all. I have one power plant where I carry steam 1,700 feet. I have not an expansion joint in the line, nor have I a steam separator. I am running automatic engines 1,700 or 1,800 feet away. My expansion running out was 13⅞ inches. It is a peculiar job, and I could not get to it in any other way than by large off-sets. There are no copper bends. It is all wrought pipes. But that system has been in use

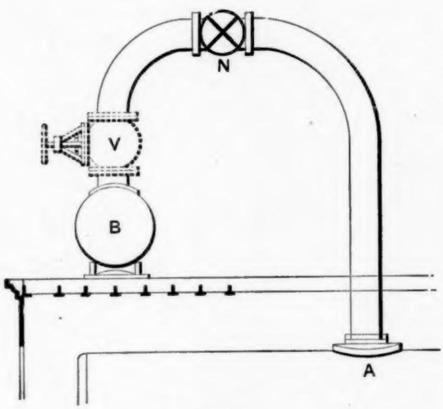
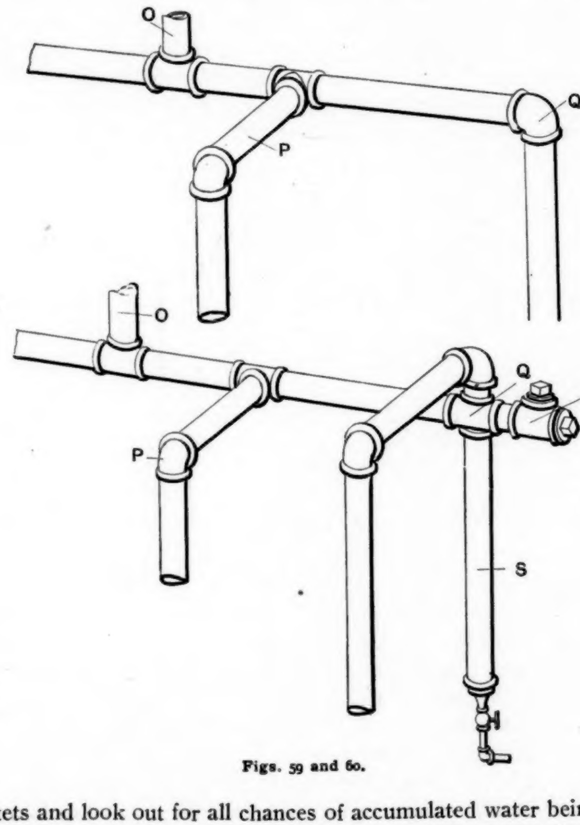



Fig. 58.

now for five years. Prof. Carpenter stated last year he had made tests on that particular system, and that the loss in transmission of steam over that line was something like three per cent. He did not know at the time that I had anything to do with it. There are seven engines and a battery of four very large vertical boilers. The vertical boilers were used on account of the ground area. I find no difficulty whatever in providing for expansion in such a system of piping and I find no difficulty in water hammer. Where I can use a first-class separator, I prefer it, but where it cannot be done, I accomplish practically the same result in this way.

Mr. Cary:—The system shown to us by Mr. Jellett is very perfect, with one exception, and I would criticise that rather strongly. The boiler upright being at A (referring to Fig. 58), he carries his steam

over and drops down to the top of steam main at B, placing the valve V as shown by the dotted lines. When the valve is closed condensation is apt to take place and it will fall on the side of the valve and remain in there—a pocket—and when the valve is opened the water will be carried along and be apt to do damage. If the valve is placed at N, where it can drain back into the system, that danger would be overcome. In laying out steam piping you should always look out for




Figs. 59 and 60.

pockets and look out for all chances of accumulated water being carried down to your engine. This system of coming out at the top of the boiler and dropping into the pipe and using a few more fittings, as Mr. Jellett has said, I have always found good practice. I have erected a great many plants, especially of late years, and I have followed that practice and have always had good results, allowing the expansion and contraction of the steam main to be taken up

on the screwed joints, and if that was only followed out more we would have less trouble from our steam mains. I had a case, a short time ago, where I had nothing to do in laying out the steam piping, but I did have something to do with installing the boiler. There were three boilers, and the mains were run off to them at right angles—that is not a matter of so much importance—and the boilers were located beyond. There were three high-speed, electric light engine connections taken from the pipe, one coming out at O, another at P, and one dropping at Q. That was very good. But when they got to the last engine—I don't know whether they gave out of fittings or pipe, but they put an elbow on at Q, as indicated in Fig. 59, and drained directly into the engine. Now, we all know that when condensation takes place it runs along the bottom of the pipe. The plant had not been running very long before they were looking around for the steam chest. To overcome that trouble, they asked me what suggestion I would make, and I told them to place a cross at Q, run out of the top of it and then come over to their engine, as indicated in Fig. 60. A place was left for future connection by using a T at R and a 10-inch drop pipe S, dropping nearly to the ground, was provided as shown, and this was drained to the trap. In that way the water collected on the bottom of the pipe would run along the length of the pipe and pass into the drop S, and that cleared the pipe of any condensed water, and it is a very positive way to get rid of it, as I know. When the engine was wrecked, of course it was the fault of the boiler, and we had a great deal of criticism, and we were obliged to run a test in order to clear ourselves. We did run a test. We needed no calorimeter in the test. The thermometer inserted in the steam pipe showed that we had superheated steam. It was absolutely dry. They questioned the correctness of the calorimeter readings; so they collected the drips all along, ran them into a barrel and weighed them out, and we found that that showed three per cent moisture. Of course, that was not priming of the boiler, but it was due to condensation. This pipe was in a very exposed condition and was run for two or three weeks uncovered. We had something like 70 or 80 feet of 10-inch pipe exposed and about 20 feet of 7-inch pipe. There was a doorway right in front of the boilers and an elevator shaft a little way behind them, and the consequence was that the wind swept through in such a way that we had every condition against us. But, after making the provision shown in Fig. 60, such an accident as the one of which I have spoken became practically impossible. Mr. Jellett has given my idea in steam piping as closely as though I had given it myself. His is excellent practice and if it is followed no trouble will result.

Mr. Jellett:—I should like to show the worst system of steam piping I ever saw. (See Fig. 61.) The boilers are not in existence—neither is the engineer nor the fireman. There were three tubular boilers built for a Southern saw mill some years ago Their work increased; the boilers were not giving the results wanted, so the owners sent for a steamfitter, I believe, and asked him to increase their capacity. He suggested that a large steam drum was the proper thing; so he built them a steam drum like the one indicated in Fig. 61. Then he said: "You use them all at one time, don't you?" "Yes." "Then use them in common. We will put the steam gauge at A; we will put valves at B, C, and D so that you can use them alternately." They had the annual cleaning and had these valves shut while they were cleaning. The boilers were filled and the fire started up. The engineer looked at the gauge and said: "These

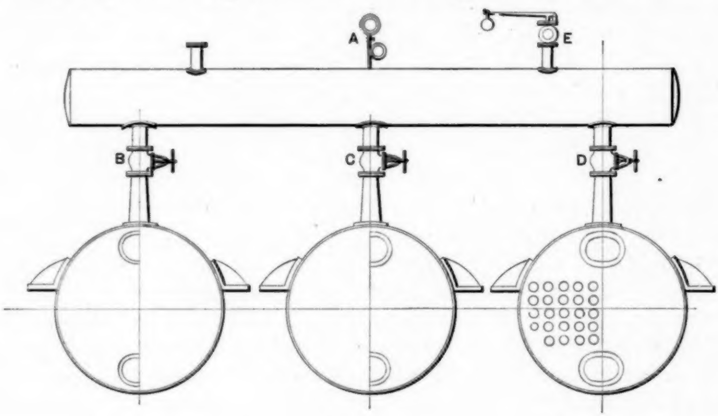



Fig. 61.

boilers are awfully slow steaming." They got on steam by and by and the saw mill and boilers and everything disappeared.

Mr. Connolly:—Where were the safety valves?

Mr. Jellett:—On the drum at E; the whole thing worked together.

Mr. Cary:—Straightway valves are being used now, and we find in a great many plants that the valve is turned upside down and the engineers wonder why they leak. Of course, the water is all the time right on the packing and will continue to leak through it. It is almost impossible to pack a valve in such a position so that it will be tight. Another trouble is that some of these straightway valves or gates—all of them, in fact—have a chamber, into which the disk at first retires when it is drawn down, and there is a considerable space left beside the space

occupied by the disk, which fills up with water, and in some of the electric light works, where very sudden demands come for steam, the water is picked out of a pocket of that kind and carried down, causing a great deal of damage. That should be looked out for, and the gate valve should never be placed in the position of which I have spoken.

Mr. Barron:—Mr. President, I should like to hear Mr. Kent on the piping of engines and boilers. That subject seems to be on the boards, and I know he has paid some attention to it. There is more than one way to pipe an engine. I should like to hear of Mr. Kent's method.

Mr. Kent:—I can only confirm what Mr. Cary and Mr. Jellett have said about the proper way to pipe. I think every one putting in a job of piping should not trust his own judgment, but should consider how easy it is to make a mistake and call in somebody else. If there is anything in the world where two heads are better than one it is in the matter of steam piping. The method of connecting two boilers with a steam drum reminds me of a case where a water tube boiler was put up. It had two water drums and a cross pipe and everything worked so satisfactorily that the owner wanted another boiler just like it when he enlarged his plant; so another boiler was put up and connected to the first by a straight pipe. The consequence was that the straight piece of pipe which connected the two boilers began moving to and fro by expansion and contraction and then the first boiler began to leak at every rivet hole. The whole boiler had to be re-riveted, the steam pipe changed, and then there was no more trouble.

Mr. Barron:—I should like to ask Mr. Jellett to explain that boiler connection to the header. You did not bend the pipe.

Mr. Jellett:—Not always; no.

Mr. Barron:—Will you show how the fittings are arranged?

Mr. Jellett:—Sometimes I use a wrought bend and sometimes a copper bend.

Mr. Barron:—In relation to the valve of which Mr. Cary spoke, one way would be to pitch back right to the boiler.

Mr. Jellett:—In taking the case shown by Fig. 58 you cannot work a straight stem vertical valve. When the valve is closed the boiler is out of service and there is practically very little condensation going on in the pipe. We want to shut off against the pressure of the manifold.

Mr. Barron:—You do not usually use a wrought bend, do you?

Mr. Jellett:—Very frequently; yes. I found that there is no difficulty in water collecting at D (Fig. 57) when the boiler is shut down. But I put it there to prevent pressure from the manifold working

over: If it was placed nearer the boiler then I would have condensation, because there is pressure continuously on the manifold.

Mr. Barron:—The way we often do is to take out a three-quarter-inch drip pipe—if we were afraid that the condensation would gather at such a point.

Mr. Jellett:—I have done that with a system of wrought pipe where I am dropping.

Mr. Cary:—Placing a drip pipe to the valve I have found to be a very dangerous proceeding. Safety depends entirely on the fireman's opening the drip valve. You cannot leave it open all the time.

Mr. Barron:—We sometimes connect the drips to a trap.

Mr. Cary:—If the drips are connected to a trap and working all right, that would do. But, concerning the connection shown in Fig. 57, I will still have to differ with Mr. Jellett, because when the boiler is shut off from the header there is generally steam still on the boiler that is cut out, and the steam which will always rise and pass the highest point will pass over to the valve V and condense. In starting up the boiler you won't open valve V until you have about the same pressure you have on the main. Then, again, the first steam coming over there will condense and lie on the valve, and I consider it dangerous practice. In draining a pipe some people have tried to incline the pipe, so that the water may run back to the boiler.

Mr. Barron:—We have often done that on short connections.

Mr. Cary:—In other words, they try to make the water run in one direction and the steam in another. If you attempt to run the steam in one direction and the water in an opposite direction, you will find that a little water will be picked up. You will get the same effect by blowing on the surface of a glass of water. That is bad practice. You should always incline the pipe so that the water and steam will run in the same direction and then get rid of the water at some point beyond.

So far as separators are concerned, in the plant indicated by Figs. 59 and 60, large separators were placed right on the engine cylinders, and they did not do the work. Separators do work, but they should be very large, to provide against all accidents. The small separators that are sometimes used are more than dangerous. A good many engineers think that, because they have a separator, they are proof against all danger of trouble from water; but, unless that separator is very large and capable of taking care of a very large slug of water, an accident is liable to follow.

Mr. Barron:—May I ask what your experience has been with separators on the loop principle, such as were shown at the Chicago Exposition?

Mr. Cary:—I have used the steam loop in some plants. With some engineers it seems to work, and with others it does not. The steam loop is a good thing if it is taken care of and under certain conditions, but the conditions should be very carefully studied before applying it and you should study the men who are to take charge of it.

Mr. Barron:—Of course, you believe that if you attempt separation it should be at the pipe, either close to the engine, or, if not that, close to both the engine and boiler—that is, two separators.

Mr. Cary:—I believe in running my pipe out to the dead end and putting a large drop leg at that end to take care of the draining from the drop leg. I consider that the best practice.

Mr. Barron:—That is the best system of separation, from your experience?

Mr. Cary:—Yes. Well, separation—that is——

Mr. Barron:—Extracting entrained water from the main steam pipe.

Mr. Cary:—No. You cannot extract the water in that way. If the water is picked up in the steam and held in suspension, it is pretty difficult to get at it. But this is taking care of the water that condenses and runs along—an excess of water that runs along the bottom of the pipe. I think that the separator, being placed right next to the engine, is all right in theory. But it is not necessary. It can be placed at any convenient point.

## XXXIII

# PROCEEDINGS

## OF THE

# AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

### FIRST SEMI-ANNUAL MEETING.

New York City, June 18, 1897.

The first semi-annual meeting of the American Society of Heating and Ventilating Engineers was called to order by President W. M Mackay at the Windsor Hotel, New York, on Friday, June 18, 1897, at 8 P. M. The proceedings were opened by the reading of the president's address.

Among those present at the meeting were the following:

MEMBERS.

Andrus, Newell P.
Barron, Hugh J.
Barwick, Thos.
Blackmore, J. J.
Bolton, Reginald Pelham
Carpenter, Prof. R. C.
Chew, Frank K.
Cobb, Geo. B.
Connolly, John A.
Cryer, Albert A.
Edgar, A. C.
Fowler, A. H.
Jellett, Stewart A.
Joslin, Herbert A.
Kenrick, Alfred E.
Mackay, W. M.
Mappett, A. S.
McMannis, Wm.
Mott, A. C.
Paul, A. G.
Quay D. M.
Russell, Wm. A.
Seward, P. H.
Sherman, Le Roy B.
Stangland, B. F.

GUESTS.

Andrews, Chas.
Andrews, J. W.
Barnard, Geo.
Davidson, W. H. A.
Foote, M. L.
Franklin, A. B.
Hanson, C. H.
Horan, M.
Irelan, Geo. P.
Leitch, Meredith
MacCallum, Percy
McNeil, Thos. E.
Meyer, Henry C., Jr.
Oakes, Thos. G.
O'Hanlon, Geo.
Raisler, Samuel
Sewell, John A.
Sill, R. Van Rensselaer
Skiffington, W. P.
Smith, H. A.
Walton, Geo. E.
Webster, Warren

The President:—First I will call for reports of special committees. (None.) Unfinished business. (None.) New business. (None.) This brings us to the first paper of the evening, which will now be

read by Mr. A. C. Mott, a member of the society, on the "Relation that Should Exist Between the Steam and Water Ratings of House Heating Boilers.

The President:—Is there any discussion on this paper?

Mr. Barron:—I would suggest that all the papers be read and let the discussion follow.

The President:—Very well, if that is the pleasure of the meeting. The next paper is one by Prof. R. C. Carpenter, on "Tests of Blowing Fans Under Different Conditions and of Different Makes."

Prof. Carpenter:—Mr. President and gentlemen: I found that I would not be able to give the necessary time to the completion of a paper to read to you, and so to-night I shall simply give you a short talk covering the nature of the investigation which we have made at Cornell University and the general result.

Two years ago, in connection with the subject of ventilation, we commenced a study of different fans in order to find not only the efficiency of the various fans made, but also to find what shapes gave the best results and what were the conditions necessary to be fulfilled in order to produce the best results. When we undertook this investigation I thought it would be a very easy matter to carry out. We have been at it now for three years, and I think we have tested some seven or eight fans. We have tested an experimental fan which we built, in various ways and shapes, and we still find that there is very much more to be done before we can make a complete report. I think the question is of a great deal of importance to us all, and I believe that there is no machine built anywhere in the world, of as much importance as the blowing fan, that has been so little investigated and regarding which there is so little known. It is also of special importance, since, if we are in the dim future or in the near future to ventilate our buildings, we must do it by some sort of fan, and hence it becomes necessary to get exact knowledge regarding them. I think, if you have erected fans and have taken data from the catalogues published by the various makers, that you have found the results actually and practically obtained were quite different from those stated in the catalogue; at least, that statement has become so trite a saying that I suppose it will pass unchallenged. In fact, I think you will find—this I do not know to be certain in regard to all fan catalogues, because I did not investigate all of them —that the figures in the fan catalogues, which show the capacity of the fans and how much air can be moved, require a fan of 100 per cent efficiency—a perfect fan. I might say that not only never has such a fan been built, but it is impossible to build one, from theoret-

ical reasons, too, as well as practical ones. Hence, it is absolutely impossible to attain the results which are given in certain fan catalogues and possibly in all of them. But, on the other hand, I do not want you to think that the fan people do not know that; when they sell you a fan they usually give you private information which is much more accurate than that which is published.

If you have looked into the subject of fans you will have noticed, that there are two very distinct types sold. Each is sold, I believe, for special purposes and they rarely come into competition. One we will call the disk fan, in which the air is received at one side and is carried in a parallel line right through the fan and discharged in parallel directions with the axis. The other is more commonly called the blower or centrifugal fan, in which the air is discharged from the edges of the blades and then is carried off by pipes or some other arrangement. The disk fans are, I think, never put in for pressure fans; that is, they are not used in places where air under pressure is required. They are generally used in places where air needs to be moved from a room and discharged into the open air —exhausting purposes principally—and this work they do very efficiently. The other class of fans is used both for exhausting air and for discharging air into pipes; that is, for moving air under pressure. The air in the centrifugal fan is received at the center of the blades and by its motion it is thrown to the outside of the fan and discharged outward. A principle was stated some years ago regarding suction fans, by Giubal, a Frenchman, namely, that if he discharged into a chimney attached to his exhaust fan he increased the efficiency very much, almost doubling it; that is, if in using an exhaust fan discharging into the air it would require a certain amount of work to move a certain amount of air, if, on the other hand, you lead the discharge from that fan into a tapering chimney you will discharge, with the same amount of work, very nearly double the amount of air. This principle, as it was stated by Giubal, has been verified and is known to be true. It applies only to suction fans. It shows that the chimney is a very useful adjunct indeed to such a fan. In this country I believe the chimney has not been used, except, it may be, in fans constructed for mine ventilating purposes; and, by the way, you should all know that the mining engineers are the men who have had the most experience with fans. They have had to use fans to ventilate mines, and it was from their practice and experiments that this fact was learned.

In regard to pressure fans, that is, the fans which deliver the air from the tips of the blades, it was found that the efficiency was very much increased if the casing was made considerably larger than the

fan. If you run a fan with a casing very close to the blades you will find that it requires very much more work to move a certain amount of air than if that casing be some considerable distance from the fan, and this has been found to be true in regard to centrifugal pumps for pumping water. The reason for this is that the air is thrown out entirely by centrifugal force. The particles of air strike the blade and are projected. If there be not room at the end of the blades not only for the air to be stored, but to get rid of its whirling motion, there will be a considerable loss of efficiency, and it has been found that in order to obtain the best result the area at the end of the casing should be about equal in distance from the wheel to the length of the blade of the fan.

In regard to our experiments I will say that we started out two years ago, first, by testing one of the commercial fans, afterwards by constructing an experimental fan, and then putting the greater portion of our work on the experimental fan. The experimental fan was in some respects very much like the commercial fan, but we built it in such a manner that we could vary the shape and size of the blades and also the form and size of the casings, those being the important things. Then we made various experiments under different conditions, in order to ascertain under what conditions we obtained the best efficiencies. I will not trouble you with all the details, but I may mention we found that a fan with straight radial blades would perhaps move the most air for a given diameter. That is, a 48-inch fan, with the blades slightly bent at the inner sides, would move the most air; but we found that when we curved the tips of the blades backward, with the inner edges running a little forward, we got the highest efficiency; that is, for the same amount of power applied we got the most air moved, although for the same diameter the other style of fan would move the most air. We also found, in regard to the casing, what I have practically announced as a general principle; that is, that the casing at the end of the fan, in order to give the best results, must be away fully the length of the blade, otherwise it will affect the result seriously. One other thing we found—which differs from what has generally been announced regarding fans, at least, in the different makers' catalogues, and I feel very certain that it is true, because it was not only true in respect to our experimental fan, but it has been found to be true of commercial fans that we tested —that the efficiency increased with the speed of the fan up to a certain point which gave us a pressure of about 2½ inches of water measured by the manometer. There was a falling off in efficiency below and above that speed. That speed corresponds in all fans to a velocity of about 6,200 feet per minute of the tip of the fan; if we

ran any of the fans faster or slower than that, there was a falling off in the efficiency. If you will look in fan makers' catalogues, I think you will find that you can move a great deal more air with a great deal less power if you run the fans at a much lower speed than I have given. Their statement does not seem to me correct. We found that by increasing the speed of the fan we moved more air with less power up to that point, and we found, further, that it was more economical to let the fan work against a pressure corresponding to something over an ounce, or, say, $2\frac{1}{2}$ inches of water, than to work freely against the air. I speak of these points because they are points which have not been considered good practice; and, too, in the putting in of a forced blast system it has been thought best to keep the velocity and pressure down very low. Consequently, this shows that in this respect our practice has not been leading to the very best efficiency.

In connection with efficiencies I should like to say a word or two about measuring the velocities of air. If you take up the mechanical system of ventilation, as perhaps you all may very soon, you must know how to measure air, and I tell you it is the most difficult thing to measure that you ever had anything to do with. You may get a great deal of practice in measuring it, and from the very fact that you cannot see it, you will find that it is very hard stuff to handle. It does not move with uniform velocity in the pipe, and that has made more trouble for us than anything else. I have been looking over some old fan tests, and I have found a record of tests where the efficiency ran over 120 per cent; that is, where the actual work of moving the air was 20 per cent higher than that done by the engine driving the fan. This test was made in a report by Prof. Trowbridge. Now, what does that mean? It means that he made a mistake in measuring the air. If you will use some instrument you will find that the air is moving five or six times faster in some places in the pipe than it is at other places in the pipe, and if you stick in your measuring tube at the spot where it is moving faster and figure on that you will have a remarkably good efficiency. On the other hand, if you will take care and put your anemometer successively in all portions of the pipe the results will not come out anywhere near that. There was another thing which troubled us, viz., the anemometers. We have three of them, one a brand new one, which came to us fully certified that it was perfectly correct, but I found on comparing it with the one we called standard last year there was 40 per cent difference, and between it and the one we called standard the year before there was about 20 per cent difference. So there was trouble right away.

Then we set out to standardize the instrument ourselves, and I might say the result showed that they were all wrong. The method we used to standardize the instruments was to swing them around through the air on a long pole. Knowing the circumference of the circle and the number of revolutions made, you have the distance it travels, and if it moves through perfectly still air the supposition is that the air would produce the same result in every case. This is the method usually adopted, to which, of course, there are some theoretical objections. Moving the anemometer through the air is not really the same as having the air moved through the anemometer.

Another method which was used for calibrating the anemometer, and which was finally adopted as giving the best results, was to check its readings by blowing the air through a large tube in which a steam pipe was so arranged that all the heat given off by steam pipe must be taken up by the air, in which case, if the number of heat units calculated as having been absorbed by the air (temperature, volume and velocity being the three factors of this calculation) was the same as the amount determined as having been emitted by the condensed steam, the reading of the anemometer was taken as being correct.

I might say that the highest possible efficiency of a fan delivering air without a casing is not over 50 per cent—that is, theoretically—because there are theoretical losses which are equal to 50 per cent of the total work put in. Consequently, we know that we cannot get very high results. By putting on a casing and putting on the chimney the efficiency may possibly be brought up to 75 or 80 per cent, although it is very doubtful, I think, if anything has passed 80 per cent.

With the pressure blowers we obtained quite uniformly nearly the same results with all the different types. That is, with three different fans, and running at the speed of which I spoke, we got an efficiency that ran from 32 to 47 per cent, varying with the conditions, 47 per cent being the highest. In order to get the best result we had to construct our experimental fan practically with square blades almost exactly like the commercial fan of that diameter; we gave it a double inlet on each side 22 inches in diameter. When taking in all the air from one side the best efficiency we could get, even at the best speed, was about 35 per cent. The increased efficiency of the double inlet indicates that the air which can be supplied through a single inlet to a rectangular fan is not sufficient to keep the casing and all of the parts full; and it would also point out, as a probable improvement on fans, that, if we were to make the fan casing on each side

slightly conical, that is, make it larger near the center than at the outside, by means of which we could admit more air through a given sized hole; that is, if our entrance in proportion to our discharge orifice would be larger, it would no doubt increase the efficiency. This fact was ascertained some years ago, but I think it has been overlooked by our manufacturers generally, because I know of no American fans built with the conical case, although some foreign fans have been built that way.

I think that from 35 to 47 per cent is just about the highest commercial efficiency of fans run under the best conditions. In proof of this proposition I might say that I have looked over a large number of tests, and I believe in hardly any case did I find that the efficiency had been higher. It has gone as high as 47 per cent only in cases where the inlet was made double or the passage for the entrance of air was made very large indeed. Practically this would mean that if the catalogue tables are based on the 100 per cent efficiency we must multiply the listed power by about three in order to find that and deliver the stated amount of air necessary to drive a given fan as printed in a given catalogue. We tested a few fans that were running in buildings and which were used in connection with hot blast, or the hot and cold blast systems of heating and ventilating. In all these cases we found the fan efficiencies very much lower than those which I have given you, or, in other words, we found that the fans were not working under the best conditions. We found in every case that the fans were running very much too slow and the efficiency, instead of running up around 25 per cent ran under 20 per cent, and yet the fans were perfectly capable of returning a very great deal more for the power put into them.

It seems to me from our investigations that there can be no very great objection to increased speed except in cases where noise is objectionable; of course you understand that the noise will always increase with the speed. I think we should all endeavor to ascertain at what speed a fan gives the very best results.

In addition I might say that we found the following propositions to be true. First, that the amount of air moved by a given fan would vary directly with its speed; that is, if you turn it over twice as fast it will throw out twice as much air. Second, we found that the work required to move the fan varied with the cube of the speed. Third, we also found, as an interesting fact, that if we take and form an equation of which the peripheral speed in feet per second—that is, the speed of the tips of the fans—is put on one side, that number was equal, in practically all our experiments, to 47 times the square root of the highest pressure expressed in inches of water—that num-

ber is about three quarters of the theoretical pressure. In other words, we found that the highest pressure we could produce was about three quarters of the theoretical, and the highest pressure can always be produced when there is no air being discharged from the fan. When there is air being discharged from the fan there will always be a less pressure than the highest, because the two things together constitute the total work of the fan.

Then there was one other useful point, which, from the fact of its being of some interest, we noticed, viz., the relation of the velocity of the tips of the fan to the velocity of the air that was driven off. I want to tell you that there is no relation between them. The whole matter rests upon this fact; if you allow a pressure to accumulate in front of your fan, as you may do by holding the air back, and then let that air discharge freely afterwards, it will move at any rate whatever and may travel three or four times as fast as the tips of the fan. In regard to disk fans the efficiency runs lower. We did not get as high an efficiency in a single case with a disk fan. I think they must necessarily run lower. More than that, just as soon as we got them working against any pressure the efficiency almost entirely fell off; that is, we were turning the fan around and moving very little air. Yet the disk fan is very much better suited for certain classes of work so that this statement is not to be understood as at all derogatory to the disk fan. The blower and disk fan form two classes, one used for one purpose and the other for another purpose.

Practically, then, our investigation shows that about the best efficiency we can get out of the blower is about 35 per cent with the single inlet, or, with a double inlet, about 10 per cent better. The use of the fan may seem to you to be more extravagant than ventilation by means of chimneys. I think we discussed that at our meeting last winter, and the table I gave you there was figured out on a supposed fan efficiency of 25 per cent, and perhaps you may remember that the fan then came out, even when I used a very wasteful engine, 50 times as economical as a chimney 100 feet high. If instead of the fan being 25 per cent, it is 33 per cent efficient our fan then becomes 75 times, instead of 50 times, cheaper than a chimney. In other words, we cannot afford, even though our fan is inefficient, to ventilate by heat. We must afford to ventilate by power. Mechanical ventilation is the ventilation which is coming and which we must learn to handle; and it is coming because it is more efficient, because it is cheaper, because it is more positive, because it is more certain and sure to give the very best results.

The paper which it was Prof. Carpenter's intention to present, but

which he could not finish in time to be read in full at the meeting, will be found on page 274 under the title "Blowing Fans."

## DISCUSSION.

Mr. Connolly:—There is just one point I should like to ask Prof. Carpenter about. He says that the hardest thing practically is to measure the velocity of air, and that at different points in the pipe he found that the velocities of the air varied. I should like to know, by taking the first test ten feet away from the fan and finding the proportion, then going 20 feet away from the fan, and so on, if there is any way of determining the variation from the inlet to the outlet. Then, coming back and making the same test over again, assuming that the engine and the fan were constantly running, would that test again vary?

Prof. Carpenter:—In regard to the constancy of the air currents, that is, whether they always remain in the same positon under the same conditions, we investigated that point, and the way we investigated it was by throwing some flour into the fan and watching it for a time when it was running. We became satisfied that they did not change to any very great extent, but they did not move in straight lines; for instance, the nearer the fan the higher velocity may come in a certain position, while ten feet further away it may be in another position. But the averages of those two positions used to come out just the same. I will read to you the results of 14 measurements made in the same section of velocities in the same pipe.

| | |
|---|---|
| 24 | 20 |
| 19 | 70 |
| 22 | 30 |
| 25 | 40 |
| 24 | 80 |
| 26 | 70 |
| 28 | 10 |
| 25 | 40 |
| 32 | 90 |
| 28 | 50 |
| 32 | 10 |
| 32 | 10 |
| 9100 | 3720 |
| 3800 | 3780 |

These were simultaneous measurements taken with a pitot tube, because we learned to work with that instrument and take accurate readings. If a person took a single one of these readings and figured out his results accordingly they would be very much in error, as there is a variation of 19-70 to 9100. The fan discharged into a square tube. The measurements were taken at a distance of about eight feet.

Mr. Jellett:—Did you not find by lengthening the pipe that the air steadied after you got a certain distance from the discharge?

Prof. Carpenter:—Yes; but if the pipe was unreduced in area we

found that even 75 feet away from the fan there were still these irregular occurrences.

Mr. Jellett:—I have found the same thing with air in circular pipes, and I have traced it by taking the temperatures of the air in the pipe, and those irregular currents continued as much as 175 feet from the fan.

Mr. Bolton:—It would almost appear as if the net result of Prof. Carpenter's tests was that by establishing a certain cushion pressure we should be able to get better results throughout the heating system, both in the fan and in the doing away with these eddying currents. Therefore, is not the best practice to establish a chamber in which we would blow under some definite pressure, and from thence take out the air as may be required? That, if practical, would seem to reduce the size of the ducts, which in nine cases out of ten cause the greatest difficulty in introducing an air pressure system in most of the big buildings that we have to deal with. I followed Prof. Carpenter's remarks with reference to the efficiency of the fans with much interest, and I will say that it has been my own practice to apply the grain of salt to the manufacturers' claims generally by cutting their ratings in half and adding 50 per cent to the power required to drive the fan.

The President:—Is there any discussion on this paper?

Mr. Barron:—I would suggest that we take up the discussion of Mr. Mott's paper.

The President:—We can go back to any of the papers that the members wish to discuss. Is there any discussion on Mr. Mott's paper?.

Mr. Barron:—I think we should like to hear from the president on that paper.

At the presidents request Prof. Carpenter took the chair, while the former discussed the paper.

The President:—We will now listen to a paper by Mr. H. A. Joslin, a member of the society, entitled "Efficiency of Heating Systems as Affected by the Removal of Air From the Radiators and Consequent Reduction of Pressure."

Mr. Jellett:—Mr. President, I move that a vote of thanks be extended to the Master Steam and Hot Water Fitters for their kindness in extending to us the use of their rooms during this meeting. (Motion carried.)

Mr. Jellett:—I am one of the committee on compulsory ventilation by legislation, and I understand that the Master Steam Fitters' Association has been considering the same subject, and I believe they are willing to entertain a proposition from us for the appointment of a

joint committee on that subject. I think the more assistance we can get the better it will be. I therefore move that we invite the Master Steam Fitters' Association to appoint a committee, which committee will work with us in furtherance of the objects our committee on compulsory ventilation by legislation have in view—either that they appoint a committee on the subject, or name an existing committee, which will work with our committtee on compulsory ventilation by legislation in the different states. (Motion carried.)

Mr. Quay:—Mr. President, I move a vote of thanks to the gentlemen, not members of this society, who have addressed us this evening. (Motion carried.)

The President:—If there is no other business to come before the society, we will now adjourn.

# XXXIV

## PRESIDENT'S ADDRESS.

BY W. M. MACKAY, NEW YORK, N. Y.

(President of the Society, 1897 to 1898)

Gentlemen and Members of the American Society of Heating and Ventilating Engineers: It is with pleasure that I welcome you to this, our first semi-annual meeting.

At the last annual meeting it was the prevailing opinion among the members that the society had reached such a point in numbers, scope, and importance as to make summer meetings a necessity, and this meeting was finally decided upon and arranged for by your board of managers; and as a number of our members from a distance were to be in the city at this time, it was thought best to hold the meeting at this time and place.

The society has grown steadily in numbers since its organization, and while the qualifications for membership are placed at a high standard by our constitution and have been rigidly enforced by our council, the number of applications received and acted upon each year indicates the standing of the society, the necessity for a society of heating and ventilating engineers, and the possibility of uniting and elevating the profession and also accomplishing great and lasting good for the public at large by a united effort to secure legislation, compelling the ventilation of public buildings to at least a healthful standard.

Our membership to-day embraces the leading men in our profession in the United States and Europe, and we have before our council for action at the present time, applications amounting in number to more than ten per cent of our entire membership. The objects of our society as laid down in our constitution are such as should receive the commendation of every heating and ventilating engineer who has the interest of his profession at heart.

Our aim is:

The promotion of the arts and sciences connected with heating and ventilation and the encouragement of good fellowship among our members;

Improvement in the mechanical construction of the various apparatus used for heating and ventilation;

The maintenance of a high professional standard among heating and ventilating engineers;

To establish a clearly defined minimum standard of heating and ventilation for all classes of buildings;

To favor legislation compelling the ventilation of all public buildings in accordance with the standard of this society;

To encourage legislation favorable to improvement in the arts of heating and ventilation and to oppose legislation inimical to the business of the engineer;

The reading, discussion, and publication of professional papers and the interchange of knowledge and experience among our members;

And to establish a uniform scale of prices for all professional services.

It will be seen from this that our objects are not selfish ones, but such as will accomplish the greatest good for the profession and the public.

We have committees appointed yearly on standards, tests, uniform specifications and contracts, and compulsory legislation.

Our committees have been active during the past year, particularly that on compulsory legislation for the ventilation of public buildings, and as a result I believe that we shall have laws enacted in five or six different states inside of another year.

The proceedings of the last annual meeting are being edited and will be published and forwarded to the members as soon after this meeting as possible.

The certificates of membership have been completed and a number of them have been delivered to the members. Those present who have not received them can obtain them at this meeting.

Our finances are in a healthy condition and our members evince a marked interest in the affairs of the society.

As our session is to be a short one, and as there is considerable to come before the society, I will not take up any more of your time, but will proceed with the next order of business.

## XXXV

# THE RELATION THAT SHOULD EXIST BETWEEN THE STEAM AND WATER RATINGS OF HOUSE HEATING BOILERS.

BY A. C. MOTT, PHILADELPHIA, PA.

(Member of the Society.)

There is published in our city (Philadelphia) a little paper called "Experience," and in its last issue a heating contractor asked for some information concerning the method used by makers of boilers for determining what the water rating of any given steam boiler should be. Inasmuch as this contractor intimated that there was considerable guess work in rating water boilers, I was asked to explain the proper method.

The contractor in the article referred to stated that he could not understand why the manufacturer rated one size boiler to carry 40 per cent more water than steam, another size of the same type at 64 per cent more, another at 97 per cent more, and so on; and I confess a little surprise, on referring to several catalogues, to find his statements more than confirmed.

In thinking the matter over it occurred to me that some information on the subject of boiler ratings might be of service to many members of this society, and I submit this paper for the purpose and with the hope of bringing out the best judgment and experience of the society on a matter of most vital interest to them as heating engineers.

The measure of the work of a power or high pressure boiler is the horse power. The measure for the low pressure or house heating boiler is the square foot of radiation. The efficiency of both types is determined by their ability to evaporate water, the boiler evaporating the greatest quantity from a given temperature with the smallest fuel consumption being the most economical.

I shall have nothing to say in this paper as to how much the grate surface, the character and position of the fire surface, or the quality of the fuel affects the performance of a boiler, my object being simply to show what relation the water rating has to the steam rating of

a boiler, and, because this relation is not understood, why many jobs are not successes.

I shall assume, therefore, for this end, that the manufacturer understands his business, and, while not admitting it, will accept as correct for my purpose the steam ratings he has given his boilers.

The manufacturer assumes, and rightly too, that under the customary guarantee in this country the steam fitter will put sufficient radiation into the building to heat it to 70 degrees in zero weather. The steam fitter, on the other hand, having put his radiation in on this basis, has a right to expect that the boiler which is rated to carry the amount of radiation required will supply it with steam at from zero to three pounds pressure by the gauge, and with a coal consumption not exceeding four to five pounds per hour per square foot of grate surface. The amount of coal consumed may exceed these amounts, but when it does in house heating jobs, there are, among several, the following reasons for it: poor fuel, poor draft, insufficient boiler capacity, and badly arranged heating surface in the boiler. So far, then, as the steam boilers are concerned the conditions are accepted by both the manufacturer and the steam fitter, and there is no room for misunderstanding; but how about hot water?

Two systems are in use for water heating; the closed tank and the open tank system. With the former, water can be carried under pressure at high temperature; with the latter, generally only to the boiling point.

The open tank system is used almost exclusively in house heating, and with this system it is generally conceded that the temperature of water in the radiators during ordinary winter weather should average about 160 degrees, with sufficient radiation to heat the building to 70 degrees in zero weather. Water at this temperature is what the majority of water boilers require in order to maintain their rating, as, under normal economical conditions, the water will leave the boiler at about 170 degrees, returning at about 150 degrees, which will make the average temperature in the radiators 160 degrees.

Turn to your boiler catalogue and see what temperature is given for the water as a basis for the rating on the boiler you are handling. Don't find it, do you? No, they are all conspicuous for the absence of information on this point. With a steam boiler you take practically no chances, as between the boiling point, 212 degrees, and five pound pressure 228 degrees, there is only a difference of 16 degrees; but with hot water the temperature of the radiation varies from 80 or 90 to 210 degrees, or more than 100 degrees. How very essential, then, that the steam fitter should know at what temperature the boiler will circulate the water in the radiation it is listed to carry,

for no one believes that a boiler rated to carry 400 feet of radiation, with water at 160 degrees, will carry 400 feet of radiation with water at 180 degrees.

The keen competition in business has caused manufacturers generally to list the maximum ability of their boilers as their capacity, and since the excess of water radiation a boiler will carry over its steam rating depends entirely upon the temperature of the water in the radiators, the manufacturer should, both as a protection to himself and his customer, publish the temperature taken for the basis of his water rating.

I will now show how to determine the water rating for any given boiler.

The amount of heat given off by radiation depends upon the difference between the temperature of the air in the room and that of the radiator. An accepted rule is, and numerous radiator tests published show, that there are practically two heat units given off per hour from each square foot of radiation per degree difference between the temperature of the air in the room and that of the radiator, when the difference is 150 degrees. From this it is very easy to determine what percentage must be added to steam radiation to heat the space with water at any desired temperature.

To illustrate: Steam at two pounds pressure makes the temperature of the radiator 220 degrees; deduct temperature of room, 70 degrees, and we have 150 degrees as the difference, which, multiplied by two (as per rule above), gives 300 heat units. The difference between water at 160 degrees and the room at 70 degrees is 90 degrees, which, multiplied by two, equals 180 heat units as the heat given off per square foot, as against 300 heat units by steam at 220 degrees, a difference of 70 per cent, consequently 70 per cent more radiation will be required to heat the space with water at 160 degrees than with steam (or water) at 220 degrees.

This shows us, too, what proportion should exist between the steam and hot water ratings of a boiler when the temperature in the one case is 220 degrees and in the other 160 degrees, so that a boiler rated at, say, 600 feet for steam would carry 1020 feet of water radiation at, say, 160 degrees.

The very vital point overlooked by many, both manufacturers and steam fitters, is that in heating a building from zero to 70 degrees (or from and to any other temperature) a certain number of heat units are required to warm the air and overcome the cooling effects of glass, wall and other exposures, and that the quantity is constant; that is, the number of heat units required is always the same, no matter what the temperature of the radiation, whether it be 220 or 160 degrees.

There being the same number of heat units required, does it not then follow, as night the day, that the boiler must remain the same, no matter at what temperature the heating medium is carried.

Just here is the explanation for many failures in hot water heating. The steam fitter figures up a building which requires, say 1000 feet of radiation; he is the lowest bidder, and, his margin being small, he begins to look around to see where he can reduce the cost. He decides to put in 800 feet of radiation and carry the water in his radiators at 180 degrees instead of 160 degrees. Here he saves 200 feet of radiation. Then he picks up a catalogue. He finds he can buy an 800-foot boiler and save another $15 or $20. And why not? Is there anything in the catalogue that would indicate to him that the 800-foot boiler will not carry his 800 feet of radiation at 180 degrees?

He puts in the 800 feet of radiation and the 800-foot boiler and congratulates himself on his shrewdness. Cold weather comes and the owner sends for him; the house cannot be made warm. The steam fitter becomes a "stoker," but with his best efforts he cannot get the water to 180 degrees, upon which the proper heating of the house depends. He sends for the boiler manufacturer—but why go on? It's an old story and "we've all been there."

In estimating for steam radiation it should be based upon a temperature of 212 degrees, which will make that of the radiator about 210 degrees. There is little value in carrying three to five pounds pressure so far as results are concerned, for while the temperature of the steam is increased as the pressure rises, the latent heat decreases, so that the total heat given off is very slightly changed. Practically the only advantage in pressure is in helping the circulation in jobs that are not perfectly piped.

The number of heat units given off by radiation grows smaller as the difference in temperature between the air in the room and that of the radiation decreases, which accounts for the increased surface necessary to give off the same amount of heat at lower temperatures.

The following table shows the number of heat units properly constructed radiation will give for the average radiator of, say, 40 to 50 feet of surface.

Heat units given off by radiation per square foot, per hour:

| | | | |
|---|---|---|---|
| With Steam or Water at | 210 degrees. | 270 heat units. |
| " Water | 200 " | 246 " |
| " " | 190 " | 222 " |
| " " | 180 " | 199 " |
| " " | 170 " | 177 " |
| " " | 160 " | 155 " |

With this data we arrive at the amount of radiation that is necessary to heat a room to 70 degrees in zero weather, with water at any desired temperature, by first finding the amount required for steam

at 212 degrees. Then if we wish to carry water at 200 degrees we add 10 per cent:

| | | | | | |
|---|---|---|---|---|---|
| Water at | 190 degrees | we add | 20 | per cent. |
| " | 180 " | " | 33⅓ | " |
| " | 170 " | " | 50 | " |
| " | 160 " | " | 70 | " |

The heating contractor should know from the amount of radiation he puts in at what temperature he must carry the water to get sufficient heat to warm the space. The size of the boiler can then be most safely determined by discarding the published water ratings in the catalogue and making his own calculations from the steam ratings, which are generally supposed to be correct. His experience with the boiler he is handling would determine this, however.

The process is illustrated in the following table by taking a steam boiler rated to carry 600 feet of radiation:

| Steam Rating. | Will carry feet of Water Rad. | When Temp. of Rad. is |
|---|---|---|
| 600 | 600 | 210 deg. |
| 600 plus 10 per cent. | 660 | 200 " |
| 600 " 20 " " | 720 | 190 " |
| 600 " 33⅓ " " | 800 | 180 " |
| 600 " 50 " " | 900 | 170 " |
| 600 " 70 " " | 1020 | 160 " |

I take it for granted that all heating contractors calculate the piping—mains, branches, and risers—as radiating surface, and unless so considered they must be thoroughly covered, as boiler ratings do not usually include mains for the very good reason that the amount of this surface varies greatly in buildings.

I must not be understood either as advocating the selection of a boiler with a rating corresponding exactly to amount of surface to be heated. The radiation put in usually is based upon zero weather and some reserve power in the boiler is required to meet the demands of colder days.

As stated, the published ratings are usually the maximum capacity of the boiler, and while a boiler just the size might give good results when first tried, the average attention given house boilers is such that in a few weeks their efficiency is impaired.

## DISCUSSION.

Mr. W. M. Mackay:—I had the pleasure of reading over Mr. Mott's paper to-day, and while I did not expect to discuss it, there are points in it which I think are worth considering by manufacturers and also by men who have had experience in hot water heating apparatus. There is only one point in the paper to which I want to take exception, and it is the same mistake—I call it a mistake, although it may not be one—that a number of men who have had experience with steam heating make when they take hold of hot water heating. My early experience was gained in steam heating, but I am now a

strong believer in and an advocate of hot water heating. One of the strongest claims for it is economy of fuel. Some parties, in establishing rules for the proportioning of radiating surface for hot water heating, take as a basis that the radiated surface should be carried at a temperature of 210 to 220 degrees. My experience is that the only advantage in hot water heating is when you carry your radiation at a lower temperature than steam, and if you heat the water in the boiler to the temperature in a steam boiler working at low pressure, you are allowing your gases to escape in the smoke flue at as high a temperature as in steam, while there is an increased cost of installation. You do get noiselessness; you do get a more uniform efficiency, and perhaps a little better result in the way of economy. You get it, however, in a way that is hardly worth the additional outlay. My experience with hot water apparatus has been that while they should be arranged with sufficient capacity in the boiler to carry the water at 200 degrees or even higher, if it is necessary to heat the building in extreme weather, the best results are obtained when you run your hot water heating apparatus at from 140 to 160 degrees in ordinary weather and up to 180 to 200 degrees in extreme weather. I was speaking to Mr. Mott about an experience that I had in heating a very large building with hot water. It had formerly been heated by steam satisfactorily, with the exception that because of lack of attention, and perhaps because of some defect in the apparatus, they did not get uniform service. The hot water apparatus was so placed that it would run at from 160 to 180 degrees in cold weather, although the temperature they wished to maintain was 60 degrees in zero weather. When the outside thermometer dropped to 13 degrees below zero they were able to maintain 65 degrees in a building containing about 1,500,000 cubic feet of air. They were not able to get a temperature of the water in the boilers higher than 185 degrees, and yet the boiler showed an economy of fuel with a more uniform temperature, heating it steadier for a longer time, than when steam was in the building. They did not fire it for perhaps eight or ten hours at night and when steam was in the building they got no heat at that time, the building cooling down, while with hot water they carried a uniform temperature and they saved between 33 and 35 per cent on fuel. My opinion is that had it been necessary to carry the water at 210, 220, or 230 degrees there would have been no more advantage in it than there would be in carrying steam at 50 pounds pressure to heat a building, when the majority of people will admit that steam at or below five pounds would be better and more economical, and some of us are willing to argue that steam at a lower pressure than the atmosphere has certain advantages over steam

at or above the atmosphere. This has been my experience with hot water. I think it is treating the subject in a way that it should not be treated when you want something different to steam and you take hot water and apply it in a way that, in the minds of the men who have had the best results from the system, it should not be applied. We would not think of setting up a steam engine and taking no exhaust from it and expect it to work satisfactorily, yet we propose to take hot water and consider it from a certain standpoint, regardless of whether it is going to give best results or not. Let us take the best system we can and apply it in the best way we can.

Mr. Barron:—I should like to get at the President's opinion of the relative heating surface of a boiler used for hot water as compared with the same boiler used for steam. I should like to know if there is any relation between them and what that relation generally is.

Mr. W. M. Mackay:—I cannot answer that question in a general way. Some boilers are better steam generators than hot water heaters. I will not admit that a boiler that is all right for steam is always right for hot water. I have heard a great many arguments on that subject. The horizontal tubular boiler makes a very good steam boiler and a very poor hot water heater. I am speaking from experience, because I have used this make of boiler for both systems. I have used boilers with more fire surface and less flue surface, while perhaps getting the same length of fire travel that you would get in a horizontal tubular boiler and have obtained better results in hot water heating than with tubular boilers. So I do not think you should compare the two systems and say that because this boiler does so well for steam that it would do equally well for hot water.

Mr. Connolly:—I should like to ask the president a question in regard to this boiler that showed economy over steam. I should like to know if it is one of those types of boilers rated for steam and also rated for hot water, as I should like to see how it works out on Mr. Mott's formula, i. e., did the boiler that you refer to also have a steam rating?

Mr. W. M. Mackay:—Yes, it had a steam rating.

Mr. Connolly:—Have you had time to compare Mr. Mott's paper to see if it agrees with your practice?

Mr. Mackay:—I have not had an opportunity, but in that particular case I believe the proportions would work out about as Mr. Mott has stated. I do think that there are boilers that you cannot consider in that way. The surface may be right for steam, but that surface may be comparatively useless as regards hot water heating, where we depend largely upon fire surface and not on flue surface.

Mr. Barron:—I was a very interested listener to the reading of

Mr. Mott's paper, and I think it has treated this subject better than it has ever been treated before. Some ten years ago I was interested in the construction of steam heating boilers, and I considered whether I should use those boilers for hot water. I found that I could carry twice as much radiating surface for hot water as I could for steam with the same proportion of grate surface and heating surface. It would never do to print the tables that way, and so I compromised by claiming that the boilers would carry 50 per cent more radiating surface for hot water than for steam and changing my tables and making no change in the boilers whatever. These boilers were not designed for hot water, and the proportions were arranged in a very unscientific way. I imagine that the whole trouble with boiler tables to-day is that most of them are formed in that way; they are not formed in a very accurate way.

Mr. Mott:—In my paper I said nothing at all about carrying water at high pressure. My remarks were based on heating with water at a temperature of 160 degrees. That, according to the heat units which can be obtained from radiation at different temperatures, the average water boiler rating (which, say, is 70 per cent greater than steam), is sufficient to heat that water to 160 degrees; but when cold days come it will be impossible to make that boiler heat the water to 200 degrees. It has not the capacity.

There are very many boilers on the market at the present time that are used for both steam and water, the only difference between them being that the steam boiler has a steam dome. My attention was called to the fact that one size represented a No. 1 boiler, which had a rated water capacity of 40 per cent more than steam; No. 3 had 70; No. 4 had 90, and No. 5 had 50. It was a haphazard rating; there was no uniformity in it, and according to the heat units which would be emitted from radiation at these different degrees, I think that your own figures will show that the percentages between them are practically correct.

Mr. Mackay:—I should like to say that during my experience in following up hot water practice I have been called upon to rate a number of different constructions of boilers, and I have always based those ratings on the grate area, the fire surface, and the application of it to the fire, the flue surface, and the application of it to the fire, and the fire travel in the boilers. I know of a number of good boilers that are rated in that way, and the ratings of them have a proportionate increase from size to size, i. e., they increase in a uniform percentage, except that the larger sizes have been found to do more work in proportion to their grate area and fire surface than the smaller sizes of the same boiler. I do not think it is right for us to

attack the ratings of all boilers. It may be that men who have come into the business without any experience in hot water heating have taken hold of a steam catalogue and put down that this boiler will do thus and so, and it may be there are some boilers that will carry their rating; that some will, while others made by the same parties will not. I have had occasion to go over the catalogues of a number of manufacturers, and my opinion is that some of them claim that they will do more than they will do, saying that there must be some deduction made in the way of mains; some say that the mains should be covered and then considered as radiating surface. They might better say that their boiler is 25 per cent over-rated. At the same time, a number as proportioned will not carry the ratings that are given, but many are proportioned in a scientific way. I know of one concern that went into the steam and hot water boiler business. They had had no experience in that line and did not know anything about it except through those whom they hired for the occasion. They got a man who was considered a competent engineer to make a test for them. He went to their factory; they had a new and clean boiler. They connected it with their factory flue, such as you will not find in any ordinary building to be heated. He got excellent results from it. The evaporation was splendid as a steam heater. He gave them a report and received his pay, and they, in ignorance of the system, based the ratings of their boiler in all its sizes on the result that this man had given them. The result was that after going through one winter they reduced their rating from 30 to 40 per cent, and I understand that it cost them a good many hundred dollars making sick jobs good and putting in larger boilers. They were, perhaps, honest in what they were doing, but they were misled by an engineer who gave them a rating and either did not explain to them, or they did not consider it, that sometimes we find a building to be heated that has a flue four by eight, where they expect you to heat a ten or twelve room house at a given temperature. Such mistakes as that may call for attention. That is, heating engineers are misled by ratings sent out to them by such a concern as the one to which I have referred. But even that concern had a uniformity of ratings, only they were based on a false standard.

Prof. Carpenter:—I have given this matter a great deal of thought, though I have not had a chance to get much practical experience. It has struck me from my observations that the best way to rate a boiler is to find out how much coal is burned per square foot of grate surface per hour, and use that as your standard. I think in cold weather no one objects to burning about four pounds of coal per hour per square foot of grate surface, and I think if you make your

maximum rating on that basis you will be all right. If you base it on five or six pounds, as you might do with a good draft, your grate will surely be too small.

On the other hand it seems to me to be a little wasteful to base your rating on flue surface, because that is putting in a bigger boiler than I think is necessary. If you undertake to base a rating on heating surface and fire surface your forms of boiler vary so extremely that it is difficult to arrive at any sort of conclusion. I spent a great deal of time once in figuring through different catalogues, and I found they varied greatly. I also found, quite to my surprise, that as compared especially with power boilers the amount of fire surface can be vastly increased in a heating boiler. The fire surface can be increased as the temperature of the fluid gets down lower. You want more fire surface and less flue surface than for a steam boiler, although it is very difficult indeed to say what the proportion should be, because it will depend upon the boiler and how much of the heat is extracted from those surfaces. Of course, you want to keep the flue temperature down as low as possible. No doubt there is a very great difference in different boilers. I have thought that a rating based on about four pounds of coal per square foot of grate per hour would do for the coldest weather and would be very satisfactory. Aside from that I have grave doubts whether any rating can be made.

Mr. Connolly:—Do you figure on four pounds of coal per square foot of grate surface per hour for 24 hours, i. e., 96 pounds per day on a low pressure heating system?

Prof. Carpenter:—My experience has been that if that amount of coal is burned it is necessary to replenish the fire about once in three hours, but people are willing to do that in very cold weather. Consequently a surface burner would probably need attention to the fire about four times a day.

## XXXVI

# EFFICIENCY OF HEATING SYSTEMS AS AFFECTED BY THE REMOVAL OF AIR FROM THE RADIATORS AND CONSEQUENT REDUCTION OF PRESSURE.

BY H. A. JOSLIN, NEW YORK, N. Y.

(Member of the Society.)

It seems to me that the members of this society should be eager for reliable information and data relative to that part of the constructive work of buildings which comes within the province of their profession, and it is with that view in mind that I ask the indulgence of the society for a few moments.

The heating and ventilation of all classes of buildings is a subject with which we are daily brought in contact, and the engineer who is able to place before his client the best and most modern methods of heating is the one who will be the most successful in his practice. To that end, we should be willing and desirous of learning all that we can about the different methods employed in heating work.

The question of ventilation I will not discuss at this time, but I do think that the result of several tests relative to the circulation of steam for heating purposes would be of interest to the members of this society.

We all know that the air in a radiator or coil seriously retards the circulation of the steam, but I think few of us know or realize the extent of this difficulty and the benefits resulting from getting it out of a radiator.

It is not the purport of this paper to go into the methods employed in getting rid of this air, but to lay before the members of this society the facts resulting from the reduction in pressure of steam in a heating apparatus, made possible by the exhaustion of the air from a steam heating plant.

We all know that without some mechanical means of exhausting the air from the radiator, pressure of steam must be carried in the pipes in order to blow or drive the air out from inside of the radiat-

ing surface, and I think you will agree with me that a heating plant of any considerable size that will circulate its steam and do its heating on a pressure of from one to three pounds represents good engineering.

The tests which I shall read you will show that the different buildings could be satisfactorily heated on pressures varying from one to six pounds above the atmosphere, but under an air exhausting system, where the air was exhausted automatically, the pressure upon the heating system was at the atmosphere and in some cases below.

In reading the results of these tests, I shall have to refer to the subject matter as having been obtained "with air exhausting apparatus," and "without air exhausting apparatus," and I trust you will follow me closely.

These tests were made by the owners' authorized representatives, and without the knowledge of the parties who were, perhaps, the most interested in the successful result of the issue.

TESTS MADE AT CHICAGO, MARCH 17-18, 1897.

| March 17. | March 18. |
|---|---|
| With Air Exhausting System. | Without Air Exhausting System. |
| Supply turned on at 5:00 A. M. | Turned steam on at 5:00 A. M. |
| Exhauster started at 5:00 A. M. | Test 19 hours. |
| Test 19 hours. | Pressure 1 lb. above atmosphere. |
| Pressure 1 lb. below atmosphere. | Used 5,270 lbs. coal. |
| Used 4,420 lbs. coal. | |

| | Temperature | | | Temperature | |
|---|---|---|---|---|---|
| | Outside. | Inside. | | Outside. | Inside. |
| | 33 deg. | 57 deg. | At 5:00 A. M. | 52 deg. | 62 deg. |
| | 35 " | 57 " | 6:00 " | 50 " | 64 " |
| | 38 " | 62 " | 7:00 " | 48 " | 70 " |
| | 38 " | 65 " | 8:00 " | 50 " | 72 " |
| | 39 " | 70 " | 9:00 " | 50 " | 73 " |
| | 39 " | 68 " | 10:00 " | 48 " | 72 " |
| | 39 " | 70 " | 11:00 " | 50 " | 75 " |
| | 39 " | 70 " | 12:00 " | 50 " | 76 " |
| | 40 " | 72 " | 1:00 P. M. | 50 " | 76 " |
| | 40 " | 72 " | 2:00 " | 50 " | 77 " |
| | 42 " | 74 " | 3:00 " | 48 " | 78 " |
| | 42 " | 75 " | 4:00 " | 43 " | 78 " |
| | 42 " | 75 " | 5:00 " | 45 " | 78 " |
| | 44 " | 76 " | 6:00 " | 44 " | 78 " |
| | 44 " | 76 " | 7:00 " | 43 " | 78 " |
| Avg. | 39.6 | 69.3 | | 47.7 | 73.8 |

NOTE:—This is a 12-story office building, having 9,600 square feet surface. Low pressure gravity return system; overhead main, down feed; main supply from boiler six inches diameter.

You will notice that in the first test there was an average difference of 29.7 degrees between the temperature of the outside and inside air and in the second test a difference of 26.1 degrees.

MILWAUKEE, March, 4, 1897.

Mr. S. J. BROCKMAN,
Com'r of Public Works, City.

DEAR SIR:—Appended hereto is report of test of heating system operated with pressure and partial vacuum, or with air exhausting system disconnected and connected.

Result, you will observe, is a saving of 17.24 per cent of coal consumption on February 25 over that of February 24, with an average temperature of 6.67 degrees lower, and an increase of 2.95 horse power of work done by electric light and elevator plant.

Respectfully submitted,
ROBT. ANDERSON,
Supt. of City Hall.

TEST OF HEATING ON FEBRUARY 24, 25, AND 26, MILWAUKEE CITY HALL.

| | Number of hours run. | Temperature in degrees Fahrenheit. | Wind Velocity. | Barometer reading in inches. | Pressure in pounds on Heating System. | Vacuum in inches on Air Exhausting System. | Work done by the Elec. Light Plant in E. H. P. per hour. | Work done by Elevator Plant in H. P. per hour. | Coal consumed in pounds. | Ashes Removed from Furnace. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | February 24— Air Exhausting System Disconnected. | | | | | | | | |
| Maximum | .. | 35.5 | 27. | 29.46 | 2.75 | .. | .. | .. | .. | .. |
| Minimum. | .. | 5. | 9. | 29. | 2. | .. | .. | .. | .. | .. |
| Totals and Averages | 24 | 18.81 | 22.68 | 29.26 | 2.25 | .. | 30.5 | 19.5 | 15,600 | 1339 |
| | | February 25— Air Exhausting System Connected. | | | | | | | | |
| Maximum | .. | 18. | 12.5 | 29.55 | .25 | 12.5 | .. | .. | .. | .. |
| Minimum. | .. | 6. | 4. | 29.37 | .25 | 8.25 | .. | .. | .. | .. |
| Totals and Averages | 24 | 12.14 | 8.49 | 29.50 | .. | 11. | 33.32 | 19.75 | 12,900 | 1732 |
| | | February 26— Air Exhausting System Connected. | | | | | | | | |
| Maximum | .. | 11. | 24. | 29.84 | .. | 12. | .. | .. | .. | .. |
| Minimum. | .. | 3. | 10. | 29.55 | .1 | 9. | .. | .. | .. | .. |
| Totals and Averages | 24 | 5.09 | 15.66 | 29.71 | .25 | 11.5 | 32.73 | 19.43 | 14,400 | 1923 |

NOTE:—This building has 24,000 square feet of radiation, is nine stories, up feed, one pipe job, temperature is regulated by thermostats on walls in rooms.

Test of Heating System at Ohio State University, Columbus, O., made by Prof. E. A. Hitchcock, M. E., assisted by William G. McCracken, chief engineer:

| | With Air Exhausting System. | Without Air Exhausing System. |
|---|---|---|
| | Date of Test | |
| | March 25, 1897. 7:30 P. M. to 7:30 A. M. | March 27, 1897. 6 P. M. to 6 A. M. |
| Duration of test | 12 hours. | 12 hours. |
| Barometer | 29.41 | 29.41 |
| Gauge pressure on main before passing pressure regulator | 21 | 26.4 lbs. |
| Quality of steam | 98.83 | 99.23 |
| Gauge pressure on main after passing pressure regulator | 0 | 6.2 lbs. |
| Pressure on air line vacuum | 6.8 | |
| Average temperature Fahrenheit, external | 31.375 deg. | 33.04 deg. |
| Museum thermometer No. 1 | 62.2 | 62.6 |
| " " 2 | 64.8 | 64.8 |
| Hall thermometer | 75.8 | 76. |
| Room No. 18 " | 74.2 | 74.17 |
| " 4 " | 82.4 | 82.15 |
| Library " No. 1 | 68.1 | 68.8 |
| " " 2 | 68.1 | 68.3 |
| " " 3 | 69.5 | 69.7 |
| " " 4 | 69. | 69. |
| " " 5 | 76.36 | 77.3 |
| Room " 7 | 76. | 76.2 |
| Total weight of return water | 8.160 lbs. | 9.578 lbs. |
| Temperature of " | 195.6 deg. | 207. deg. |
| Steam used by exhauster per hour | 36 lbs. | |
| B. T. U. per hour for heating | 607.340 | 783.490 |
| Per cent saving in B. T. U. | 14.4 | |
| Per cent saving by weight of steam | 14.8 | |

This test was made on one of a series of eleven buildings, and the steam was carried in a tunnel from boilers 1800 feet away, with a pressure reducing valve at the building.

I might give you the data of other tests upon different plants throughout the country, showing practically the same result, but I think I have shown enough to convince us that not only the elimination of air from a heating system, but a reduction in the pressure used, sometimes even below atmosphere, has a very much larger bearing upon the successful and economical working of a steam heating plant than many of us have heretofore realized.

## DISCUSSION.

Mr. Barron:—I should like to hear from Mr. Joslin in regard to the character of the device used for exhausting air from the radiators.

Mr. Joslin:—I think I mentioned in my paper that I did not propose to go into the method of exhausting the air.

The President:—I might say here that it is not our intention as a society to advocate or advertise any particular system of heating or

ventilation; we eliminate names and that possibly accounts for Mr. Joslin's modesty in the matter.

Mr. Barron:—Does Mr. Joslin use a steam pump to exhaust the air from his tail-end pipe in the university?

Mr. Joslin:—Sometimes.

The President:—In that particular case?

Mr. Joslin:—I do not know. I will say, gentlemen, that I did not make those tests myself. They were made by Prof. Hitchcock, and I presume he could give Mr. Barron all the informatioin desired.

Mr. Quay:—I should like to ask, in regard to the results obtained from heating at or below the atmosphere, how they compared with heating at from two to five pounds—whether we get as good results from that pressure as we do from the higher pressure.

Mr. Bolton:—I have had some experience, Mr. President, and I think the result is entirely satisfactory, and I know of no reason why we should want to have it any higher than atmospheric pressure. The results speak for themselves. In the case of very large buildings the problems that have been presented are really acute, and if circulation at that very low pressure can be obtained in them, why I presume it can be obtained under any circumstances. I might add that there is one facility that you get by the low pressure system with positive circulation, and that is that you are able to swing the current of heat from one side of a building to the other. That is one feature that is unique with them.

Mr. A. G. Paul:—I think that the varying conditions governing the heating of a building under pressures at or below the atmosphere should have considerable study on the part of the society. We have proved that in buildings where it formerly required 40 pounds pressure to circulate and heat the building, with the same amount of surface and without material change in the piping, steam is now circulated at the atmosphere under the system of simply removing the air and securing the full benefit of the surface, and the buildings are satisfactorily heated without additional radiation. This system has also been applied to plants covering large territories, to old plants which have been in existence a long time, to plants where steam was carried for thousands of feet through all kinds of piping, and the water of condensation returned to the boilers. We have cases where steam is circulated at the atmosphere in pipes only 21 inches under ground and poorly protected, where 40 pounds pressure was formerly necessary to circulate, and they are now circulating and heating at the atmosphere, and the water of condensation is returned to the boilers at a high temperature. On a modern 16-story building it was found that steam could be carried to the top of the building with-

out pressure above that of the atmosphere and the water of condensation delivered to the feed water heater within two degrees of the temperature of the steam passing out, thus producing and maintaining a circulation throughout the entire building at a loss of practically nothing but the latent heat of the steam. We have buildings working under the system wherein the steam is circulated and the building heated at from three to four pounds below the atmosphere, and if you should ask the engineer to let the system circulate at the atmosphere, he would tell you, "I have got to increase my fire and I cannot do it without putting a heavier fire under the boilers," and this, although the boilers at the time were running at 110 pounds pressure, the firing being perfectly uniform. We also have buildings working under the system where they have only a limited amount of exhaust steam and they have a system of thermostatic regulation, and instead of supplying live steam through the reducing valve whenever the exhaust steam is not sufficient to supply the amount of surface brought into use by the opening of the valves on the radiators at atmospheric pressure, they use the expansion of the steam in the mains and supplies and allow no live steam to enter, thus effecting an economy. Of course, by the expansion they reduce the pressure on the entire system, but all the radiators are filled completely with steam, although at a lower pressure. It is the endeavor in producing these facts to give the society the benefit of any experience that may be obtained in this line, and I think the subject of the paper under discussion well worthy of your careful investigation, and I think the subject of the economy in reduction of pressure in either live or exhaust steam to the lowest practical point, and the return of the water of condensation from the system at or near the temperature of the steam flowing out, can be accomplished with less loss of heat units by the system of which this paper treats.

XXXVII

# BLOWING FANS.

BY PROF. R. C. CARPENTER, ITHACA, N. Y.

(Member of the Society.)

The demand within the past few years for a positive and ample supply of pure air in all portions of every inhabited building makes this subject of considerable importance at the present time. There are other means of moving air than by the use of the fan, but such means are uncertain in results and, although the fan does not possess a high efficiency, are even yet more costly in operation. The writer had the pleasure of calling the attention of members of the society, at its meeting held in the winter of '96-'97, to the fact that the fan was many times more efficient for the moving of air than a chimney; that is, a pound of coal burned under a steam boiler and generating steam therein, the steam being used to drive a steam engine and that in turn made to propel a blowing fan, would deliver, under ordinary conditions, 50 times as much air as the same amount of coal burned in a chimney 100 feet in height.

The methods of moving air may be divided into two different classes; first, that in which heat is used to rarify or expand air in a chimney or passage, which action causes a current that depends both upon the temperature and the height of the column of heated air. Second, mechanical means of ventilation, which includes various kinds of machinery driven by power and used for the purpose of compressing or moving air. Under this latter head will be found blowing engines of various forms and of both reciprocating and rotary types. While some of these engines may possibly be useful in the field of ventilation they are not at present of much commercial importance for the reason that the expense of construction for a given capacity is such as to preclude their use, except in rare cases. The term "blowing engine" is in this classification made to include not only the piston compressor or blower having reciprocating motions, but also the positive rotary blower, of which there are many kinds on the market. The positive machines in the above class possess a great advantage over those to be described later where high pressures are required, but on account of their complexity are of less value than the simple

fan blower where large amounts of air are to be moved with little or no increase in pressure.

The fans or blowers consisting of a single wheel with vanes of different forms and operating without valves are of the greatest value in this respect and principally used for moving air for ventilating purposes, and will be the only class considered in this discussion.

The ventilating fans can be divided into two general classes, which differ somewhat in structure according as they belong to one or the other class, and these classes will be termed, in accordance with their ordinary notation, exhaust fans and pressure fans. The exhaust fan is designed to remove the air from a given space in such a manner as to slightly reduce the atmospheric pressure within that space. The pressure fan is, on the other hand, intended to deliver air into a given space in such a manner as to slightly increase the atmospheric pressure in that space. In the one case the principal work of the fan is done by lifting or sucking the particles out of the given space and in the other by pressing or forcing the particles into a given space. It has been found from experience that certain general forms of fans are better adapted to each kind of work. Where the particles are to be forced against considerable pressure there must be high velocity of the periphery of the blades, and generally the delivery of air must take place from the extremity of the blades and from parts having a uniform motion. On the other hand, where air is delivered into a space not having an excess of pressure above the atmosphere, the velocity may be lower, and it is not strictly necessary that all portions of the fan coming in contact with the air should move with the same velocity. In the first class the air is delivered radially and in the second class the air is delivered in the plane of the axis of the wheel; those of the first are generally termed "blowing" fans and of the second "disk" fans respectively. The form of the air vanes differs materially in different makes of each class.

In both classes of blowing fans the sole force which is available in moving the air and in producing the pressure is that due to the centrifugal action of the fans. In every case a considerable portion of this force is wasted in directing the particles of air in the wrong direction, another portion due to striking the particles of air while on their way into the fan in such a manner that they cannot enter freely, and another portion is wasted in friction of machinery and in the friction of the air in passing through the passages. Altogether in the best fan there is nearly as much or more work wasted than usefully applied, so that the efficiency of blowing fans will necessarily be found low.

The work done by a fan will be manifested either in producing mo-

tion of air at a high velocity, or a change of pressure accompanied by the generation of heat, and these phenomena may be noted separately or together. The work of compressing air consists in moving the particles of air into closer contact and is always accompanied with the liberation of heat. It is similar in nature in many respects to the work of moving the air, although in the latter case the particles of the air are simply moved forward through space without being brought in closer contact. Since a portion of the work of the fan is utilized in producing pressure and another portion in producing velocity, it becomes quite evident that, for a given amount of work, as the one increases the other will diminish, and this important principle should in every case be recognized in dealing with fans.

Since the fans operate without valves of any character, and since the fluid which they are moving is highly elastic in its nature, it follows that changes in pressure depend immediately on changes in velocity of the fan, consequently the fan must be kept in continual operation during the entire time that air is to be moved.

In regard to the action of the "disk" fan, as ordinarily constructed, the air is delivered at different rates of speed from various portions of the fan. The air delivered near the periphery moves with a speed

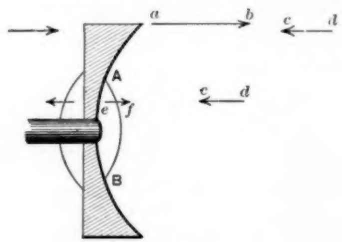



Fig. 62.

due to the velocity of the outside portion of the fan, that near the center moves with a proportionately less velocity, and that at the center with no velocity.

If the air is delivered against any pressure whatever, since the pressure acts uniformly over the entire cross section of the fan, the reaction is quite certain to produce a motion in the opposite direction near the axis.

Thus in Fig. 62 the air is delivered near the outside with a velocity which is equal, say, to ab; from near the center with a velocity equal to ef. If the fan is working against no head or pressure all this will be useful, but if the pressure be represented by a line cd, greater than ef, the result will be a loss of efficiency due to a rectrograde or a current moving in the wrong direction. As the force acting is radial in direction this probably can not be entirely overcome by the use of

disks or guards, although they will doubtless lessen the bad effect of the back current.

While the "disk" fan has a use similar to the screw propeller inverted, the inventors in perfecting it seem to have worked on the development of another idea. The screw propeller by its motion in the water crowds the ship forward, its power being obtained by turning in a body of water, so that its motion is analagous to a bolt with a screw turning in a solid nut. In order to accomplish best results every portion of the blade has to be made to the same pitch, or, in other words, of such a form that one revolution of any part of the blade would carry the ship forward the same distance. This requires each blade to have a modified helicoidal surface and to be built with an angle which, measured from the axis of the wheel, grows flatter as the distance from the center increases. The simple law of construction, as stated, has to be varied extremely in practice with the propeller in order to gain highest results. In the case of a disk fan it would seem that a similar construction would be of greatest efficiency, but it is not believed or claimed that any disk fans are as efficient as the screw propeller, or even as the radial pressure blower under best conditions.

The following description of the theoretical action of centrifugal fans, as viewed by different experimenters, is taken from the thesis of Messrs. Haines & Hobart.*

### HISTORY OF FAN CONSTRUCTION.

In the early history of the centrifugal fan, when its more prominent use was the ventilation of mines, the questions of first cost and durability were the prominent ones; this was especially true at the coal mines, where the cost of steam power was not a very large item, and very close study of the actual running of the fans was not attempted.

As soon, however, as rival makers began to place their products in operation in neighboring coal fields attempts to obtain experimental data were made. Many experiments by individuals and by committees of engineering societies were made.

An insufficient knowledge of the principle of blowing fans seemed a large obstacle to the determination of reliable results, as did also the lack of accurate and uniform methods of research, and much controversy and many conflicting claims resulted. These, by their general indication, in a measure directed the lines for improvement and progress.

As early as 1847 Mr. Buckle gave a paper before the Institute of

* Test of Fans, Sibley College, 1896.

Mechanical Engineers, in Birmingham, Eng., showing results of experiments made upon a small fan. He gave results and data as to power, speed, quantity of air delivered, and advised general proportions for fans, namely:

Widths of vanes equal to ¼ diameter of fan.
Length " " " " ¼ " " "
Diam. of inlets " " ½ " " "

(but with longer blades for higher pressures). These proportions, even at the present date, are not uncommon in general practice.

About the same time Mr. John Downie experimented with fans, reading a paper before the Institution of Engineers in Scotland, in which he pointed out the advisability of closing and connecting the sides of the vanes and advocated the careful study of suitable adaptation of the parts of the fan.

In 1857 Dr. W. J. M. Rankine, before the same society, indicated the fact that the most economical fan should have blades so formed as to change the direction and velocity of the air as gently as possi-

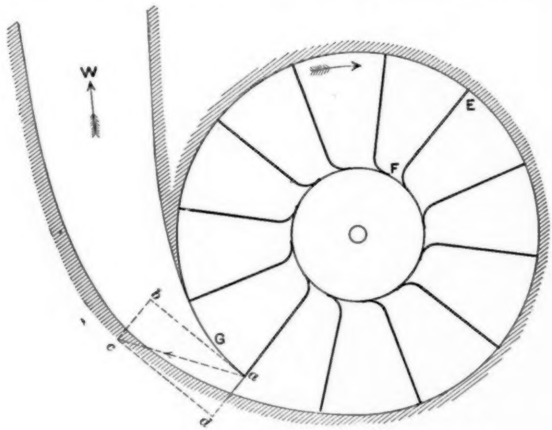



Fig. 63—GUIBAL FAN.

ble. He advised a large casing about the fan to reduce the velocity of the air by allowing it to travel several times around the fan before leaving the case. This lowering of the velocity was carried out later by M. Guibal, who used a conical "expanding chimney" upon the discharge orifice of his ventilating fans, as indicated in Fig. 63.

General Morin, in his Des Annales Conservatorie des Arts et Metiers, 1862, concluded that the volume of air delivered by a fan varies directly as the speed.

In 1865 an editorial in the (London) Engineer first calls general attention to the fact that the laws governing air and water are the

same, slight differences of form of apparatus having, however, less effect in fans than in centrifugal pumps. Any complete theory of the centrifugal fan was still unattained. Attempts had been made to formulate such a theory, and the dependence of the fan's action upon the laws of the flow of fluids was evidently known.

In 1872-78 M. Daniel Murgue, a French engineer, developed a theory of the centrifugal fan which, while being simple in demonstration, seems adequate.

THEORY OF THE FAN.

Consider the ideal centrifugal fan, without casing, rotating at a uniform velocity; to determine the theoretical initial depression, H, of water gauge due to the speed of periphery, it is seen to be made up of the algebraic sum of all the different depressions caused by the action of, first, the depression due to the speed, $v_0$, to which motionless air is brought before reaching the blades; this, from the law of flow of fluids, equals

$$\frac{v_0^2}{2g};$$

second, from the slowing action of the air between the inner and outer extremities of the blades, due to the increased area of passage, the air entering at a speed equal to $v_1$ and leaving at $v_2$, the gain of depression equals

$$\frac{v_1^2 - v_2^2}{2g}$$

The speed of entering, $v_1$, may be considered as the resultant of a tangential speed, w r, (this being equal and opposite to the tangential speed of the blades at their inner edge, r being the radius and w the angular velocity) and the radial speed $v_0$. (Here the ideal vane takes the air without shock.) Then

$$\frac{v_1^2}{2g} = \frac{v_0^2 + w^2r^2}{2g}$$

The centrifugal force may be found by summing the centrifugal forces upon all the small particles dx (with base S and density $\delta$) at the distance x from the center

$$dF = \frac{\delta S\, dx\, w^2 x}{g}$$

Noting that dF = S dh, we have

$$\int_0^h S\, dh = \frac{\delta S\, w^2}{2g}\int_r^R x dx$$

and the depression, h, due to this cause is determined by means of the formula

$$\frac{w^2 R^2 - w^2 r^2}{2g}$$

in which R and r represent the external and internal radii of fan. Adding all the terms we have,

$$H = \frac{v_0^2}{2g} + \frac{v_0^2}{2g} + \frac{w^2 R^2 - w^2 r^2}{2g} + \frac{w^2 r^2}{2g} - \frac{v_2^2}{2g}$$

Calling the tangential velocity $wR = u$

$$H = \frac{u^2}{2g} - \frac{v_2^2}{2g}$$

This is true whatever curve the vanes may have.

In the above expression u is the tangential or peripheral velocity, in feet per second, of the external part of the fan, and v the corresponding radial velocity of the air. A study of the expressions shows that the greatest depression is produced when v, the radial velocity of the air, is zero, or, in other words, when the air is delivered from the fan with the least velocity possible in the direction of the radii of the fan. To reduce this loss as much as possible designers have curved the blades backward, so that the blade is in shape nearly tangent to the outer circle of the fan; but in doing this they are likely to reduce the power of the fan; hence it becomes necessary to increase the speed to secure a given amount of work, thus also increasing the other losses.

Practically the best results are obtained with the blowing fan by having the air delivered, with the least velocity and highest pressure possible, into a pipe or reservoir from which the air is taken and allowed gradually to expand. The best form of the expanding pipe is that shown in Fig. 63, and is known as the Guibal chimney. This was originally designed for an exhaust fan, but recent investigation shows it to be equally efficient for a blowing fan.

The following formulas show the depression produced by a Guibal chimney:

If V is the velocity of the air just as it leaves the fan at the throat of the discharge pipe, $V_2$ the radial velocity of discharge, and W the speed at the end of an enlarging discharge pipe, we will have, by the theory of Bernouiln, an increase of pressure

$$\frac{V^2}{2g} = \frac{W^2}{2g} = h$$

but $V_2 = W_2^2 + V_2^2 - 2W V_2 \cos. a$, a being the angle at which the blades strike the exterior circumference. Substituting this value of $V_2$ we have

$$\frac{W^2}{2g} + \frac{V_2^2}{2g} = \frac{WV_2 \cos. a}{g} = \frac{W^2}{2g}$$

For increase of depression due to the expanding chimney of Guibal

$$H = \frac{u^2}{2g} = \frac{V_2^2}{2g} + \frac{W^2}{2g} + \frac{V_2^2}{2g} = \frac{WV_2.\cos.a}{g} = \frac{W}{2g}$$

$$\text{or } H = \frac{u^2}{g} = \frac{WV_2\cos.a}{g} = \frac{W}{2g}$$

This, then, expresses the theoretical depression of the Guibal ventilator, which is typical of the fan with expanding chimney. When the vanes are radial at their outer ends, so that the direction of $V_2$ is radial, cos. a = o and we have

$$H = \frac{u^2}{g} = \frac{W}{2g}$$

This equation shows clearly that the best theoretical vane is radial at its outer extremity.

Now imagine the expanding chimney infinitely prolonged, then W = o and the total depression developed by the ideal centrifugal fan equals

$$H = \frac{u^2}{g}$$

or, as Murgue states, "the theoretical depression of the perfect ventilator is double the height created by the tangential speed."

In the real case we must introduce a coefficient of reduction, K, and

$$H = \frac{K\,u^2}{g}$$

K being the proportion of the real initial depression to the theoretical depression of the fan.

The above shows that the uncovered fan can never have an efficiency of 50 per cent (manometrically), while the covered fan may realize a much higher efficiency.

The use of the word depression in the above demonstration denotes the difference between suction and delivery prssures, the word compression might as well have been used, thus indicating a blowing fan instead of a suction fan, as implied by the nomenclature employed. To establish a general formula for the manometric depression of a ventilator Murgue develops the "equivalent orifice" method, proceeding as follows:

Let a = an orifice in a thin plate of such area that its resistance to the passage of a certain quantity of air equals that of the external resistance against which the fan operates. o = an orifice equivalent to the resistance of the fan itself.

Let Q = quantity of air passing.
V = velocity of air passing through a.
$V_0$ = velocity of air through o.
h = head in feet of air to produce V.
$h_0$ = head in feet of air to produce $V_0$.

$$\text{then } Q = .65\,a\,V = .65\,a\,\sqrt{2gh}$$
$$= .65\,oV_0 = .65\,o\,\sqrt{2gh_0}$$

then

$$o = \frac{Q}{.65\,\sqrt{2gh_0}}$$

Now the total theoretical head = H

or $$H = h_0 + h$$

$$\text{from above } \frac{h_0}{h} = \frac{a^2}{o^2}$$

$$\text{and } h = H - \frac{h\,a^2}{o^2} = \frac{H}{1 + \frac{a^2}{o^2}}$$

Q then becomes

$$Q = \frac{.65\,a\,\sqrt{2gH}}{\sqrt{1 + \frac{a^2}{o^2}}}$$

Considering the value of H previously obtained (ie)

$$H = \frac{K\,u^2}{g}$$

$$h = \frac{K\,u^2}{g\left(1 + \frac{a^2}{o^2}\right)}$$

$$Q = \frac{.65\,\sqrt{2}\,Kau}{\sqrt{1 + \frac{a^2}{o^2}}}$$

Thus the fan "being defined by its tangential speed and its orifice of passage," o, and the orifice of the external resistance, a, being constant for any given conditions, the other terms being constants, these formulæ show two laws:

First, the volume yielded varies as the speed of rotation.

Second, the depression varies as the square of the speed.

### TESTS OF BLOWING FANS.

On account of the great discrepancy in the published results of various fan makers and the actual results obtained with the same fan, it was determined to make a series of experiments and, if possible, determine the conditions under which each fan gave its maximum results and also the power required and the efficiency for various fans.

In order to make the test entirely independent of commercial con-

siderations, it was decided to make an experimental fan in which the casing and the parts could be varied to a considerable extent. The fan was made with radial arms and with blades of rectangular section. The casing was so constructed that it could be changed in form and size as required. The blades were made so that they could be readily removed and others of a different form inserted. A diagram showin the general arrangement of fan is presented in Fig. 64.

The work delivered to the fan was measured by using a dynamometer; the work done by the fan in moving air was obtained by measuring the velocity and the pressure and computing the results from the well known relation between work and velocity. The dynamometer used was accurate and delicate and its readings were checked by comparison with a Prony brake, so that little difficulty was experienced in measuring the power supplied the fan.

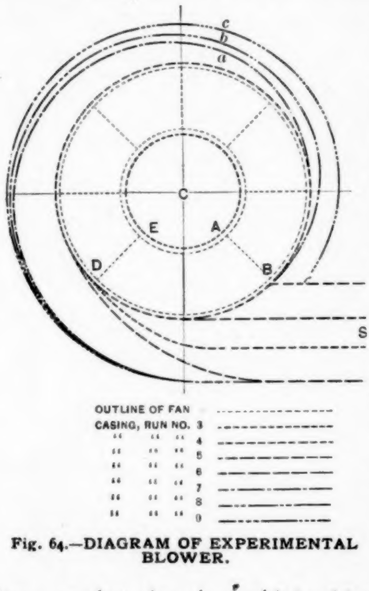



Fig. 64.—DIAGRAM OF EXPERIMENTAL BLOWER.

Considerable difficulty was experienced in standardizing the various anemometers used, and a great variation was noted in the readings given by instruments of different makes even when certified as correct. After trying various ways of standardizing anemomenters, the following method was adopted as giving most accurate results. A coil of steam pipes was arranged in a wooden box, so that the air could be blown freely over them. Steam was passed through the coil, and the amount of condensation was accurately determined. This latter was reduced to heat units by use of a steam table. As all the heat given out by the steam must be taken up by the air we should evidently have the same results were we to multiply the velocity of the air by the area of the pipe, by the weight per cubic foot, by the specific heat of air, and by its rise in temperature.

If, on the other hand, the velocity be not known and all the other quantities are known, the velocity can be obtained by dividing the number of heat units in a given time by the other quantities. By

comparing the velocity computed in this manner with the average of a large number of readings of the anemometer taken in various portions of the section, and for different velocities of air the coefficient of the anemometer may be obtained quite accurately.

In the form of a formula

$$v = \frac{H}{ta\ ws}$$

In which H is the number of heat units taken up by the air per second, t the increase in temperature of the air, a the area in square feet, w the weight of one cubic foot of air, s the specific heat of air (0.238), v the velocity of air in feet per second. After one anemometer has been standardized others may be standardized by direct comparison. As the friction of these instruments is likely to change from time to time it is necessary that they be standardized frequently.

The Pitot tube, Fig. 65, is very well adapted indeed for high velocities, say, about 500 feet per minute, but is poorly adapted for low velocities, since the change in the level of the water columns, if small, cannot be read with accuracy.

If we consider the theoretical formula for the Pitot tube as $v = \sqrt{gh}$, we shall find that if h be taken in inches of water v will equal 98 $\sqrt{h}$. By calibration we found that the reading would be $v = 57.8 \sqrt{h}$ for temperature of 120 degrees.

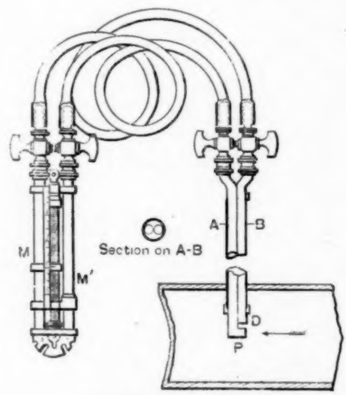


Fig. 65. PITOT TUBE.

For other temperatures the coefficient should be multiplied by the following factors:

| | | |
|---|---|---|
| 32 | degrees | .920 |
| 60 | degrees | .95 |
| 80 | degrees | .965 |
| 100 | degrees | .985 |
| 140 | degrees | 1.017 |

For most of the work the Pitot tube proved rather more reliable than the anemometer, and it was frequently more convenient, since it could be inserted into any required position in the cross-section of the tube. The velocity of the discharged air was found to vary in different portions of the tube extremely, and hence it was necessary to take a very large number of observations at each cross-section and average the results.

GENERAL RESULTS.

The form of tube used in this work is shown in Fig. 65, and a diagram for reducing the readings without calculation is shown in Fig. 66.

The general results substantiate the following principles:

First, the volume of air discharged varies directly as the speed of rotation.

Second, the depression or variation in pressure varies as the square of the speed, that is, $v = c\sqrt{gh}$ when h is expressed in inches of

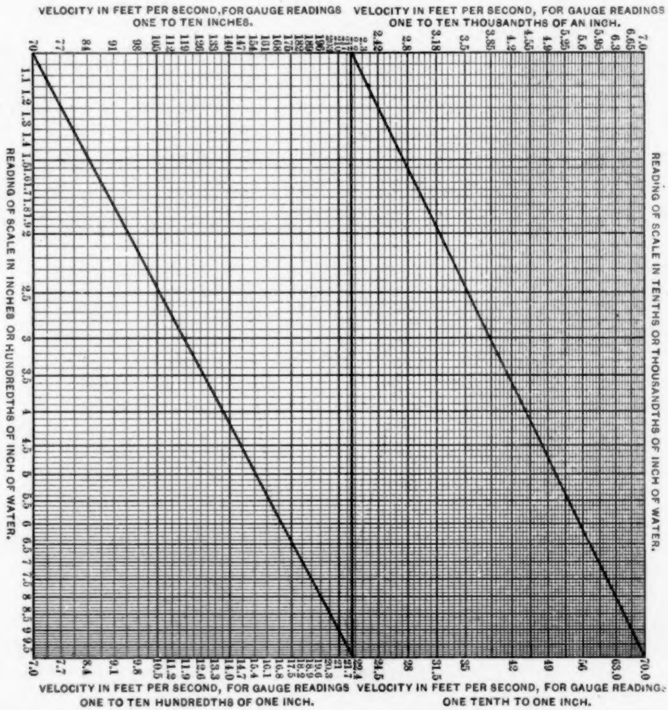



Fig. 65. **DIAGRAM FOR REDUCING READINGS OF PITOT TUBE WITHOUT CALCULATION.**

water and v is peripheral velocity in feet per second at 70 degrees F. We found from experiment that the theoretical constant, c, as given before, showing the relation of the peripheral velocity of the blades of the fan to the pressure, should be divided by 1.4 for a pressure of one inch of water and by 1.7 for a pressure of eight inches of water, that is, $v =$ from $56.5\sqrt{h}$ to $81\sqrt{h}$ dependent upon the pressure.

Third, the power varies with the cube of the number of rotations. In respect to these various propositions our experiments would agree with those of Murgue. As to the best forms of blades to secure the highest efficiency our results are essentially different. The fan described by him was that designed by Guibal and had radial blades with a curvature at the inner edge. (See Fig. 63.) While we obtained the highest pressure with blades of this character and greatest delivery of air, we obtained the highest efficiency, that is, the greatest amount of air in proportion to the power required, with blades bent backward at the extremity. We also found that the area of the inlet had a marked influence on the efficiency with a fan with rectangular blades, in which the external diameter of the blades was 48 inches, the internal diameter 24 inches, the width of the blade 18 inches, number of blades eight, area of each blade in each case 1½ feet. Although the inlet was made very nearly the size of the inner radius of the fan, yet it was found possible to increase the efficiency from 32 to 45 per cent by constructing a double inlet, which was done by making an open-

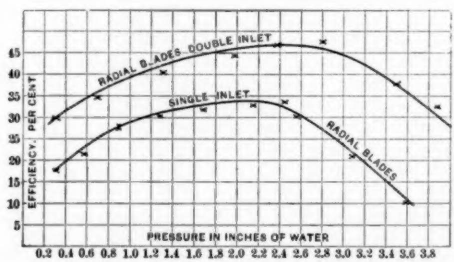



**Fig. 67. DIAGRAM SHOWING RELATION OF EFFICIENCY TO PRESSURE IN DELIVERY TUBE. VELOCITY 6200 FEET PER MINUTE,**

ing on the opposite side of the casing. All of the tests show an increase in efficiency with increase in rotative speed of the fan, and this held true not only for the experimental fan, but also for four fans made by various companies, and this can probably be considered true for all fans with a peripheral speed not less than 6,000 feet per minute. It is quite evident that at some point the speed of the fan will become so great as to produce a great amount of slip, in which case the efficiency would fall off. The form of the casing has a great influence on the results, and it is evident from the experiments that the area of the casing outside of the space taken by the fan should be sufficiently large as to permit a free delivery of all the air contained in the fan into the outside space; the air is swept along by the reduction

in pressure and the motion of the blades into the delivery tube. A casing of a spiral form set close to the fan blades at the point of cut-off, but with its distance increasing until it is equal to the length of the fan blades from the fan at the point of discharge would seem to give excellent results.

The velocity of the discharged air was found to bear little or no relation to the peripheral velocity of the blades for the reason that a reduction in pressure generally occurs between the fan and the point of discharge, and the velocity of discharge is in part due to the reduction in pressure which acts to increase the rate of flow materially, so that the velocity of the moving air will be found to bear nearly every relation to that of the periphery of the fan.

The efficiency of the pressure blower increases with increase of pressure, at least until the pressure reaches about two inches. (See Fig. 67.)

The relation of efficiency to pressure is shown by the curves (Fig.

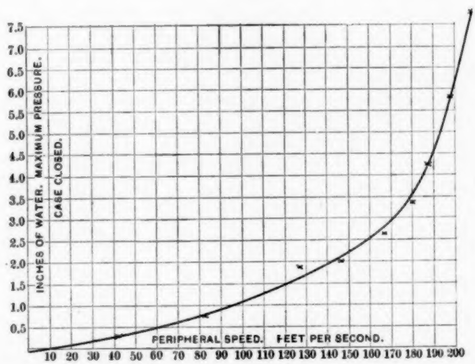



**Fig. 68. TEST WITH BLOWING FAN. RELATION BETWEEN PERIPHERAL SPEED AND PRESSURE IN INCHES OF WATER.**

67) for the pressure blower with radial blades and with single and double inlet. It will be noted that the highest efficiency was obtained in both cases with a pressure of 2.4 inches of water; this corresponds to a peripheral velocity of about 6,000 feet per minute and indicates that it is generally better practice to operate a fan at such speed as to maintain a pressure of 2.4 inche of water, than to allow it to work against a lower pressure.

Fig. 68 shows the relation between peripheral speed in feet per second and the pressure in the manometer in inches of water. Without entering into a detailed discussion it may be sufficient to

say the investigation shows that a higher efficiency is to be obtained by operating pressure blowers with a speed not less than 100 feet per second and in maintaining a pressure in the principal chamber into which the air is delivered of not less than two inches of water; this, it may be said, will permit cheaper construction, since smaller fans and smaller pipes may be used for conveying air than are now ordinarily employed.

## TESTS OF DISK FANS.

Under my direction Messrs. Parker & Wilcox also investigated the efficiency of several different forms of disk fans. I will not at this time undertake to describe the investigations in full, but will merely state that they found the efficiency of this class of fan to be less than that of the centrifugal blower type and, furthermore, that the efficiency diminished as the pressure increased. The disk fan with the helicoidal-shaped blades showed an efficiency under best conditions of 25 per cent, while the disk fan with straight blades shows, under the same conditions, an efficiency of 14 per cent. In all cases the highest efficiency was found with a mean peripheral speed of 5,000 to 6,000 feet per minute. The efficiency of all disk fans fell off very rapidly with increase of manometer pressure, and good results were impossible when the manometer pressure exceeded that of the atmosphere by one-half inch of water.

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